THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 64 Thursday, January 30, 1941 No. 1276

PUBLISHED WEEKLY

Subscription Terms (Home and Overseas): 21s. per annum.
All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.

WARTIME ADDRESS
to which all communications should be sent until further notice :—
3, Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address: "Zacatecas, High Wycombe."
Telephone: HIGH WYCOMBE 1792 (3 lines).

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The Psychologist and Industrial Recruitment

Assuming that the foundry industry must in the future recruit much of its personnel from the ranks of the junior technical schools, there was naturally some interest for us in studying "Tests for Selecting Secondary and Technical School Children," an article by Mr. Patrick Slater in the January issue of "Occupational Psychology." Quoting from the Spens Report, the author draws attention to the fact that technical schools receive those children who have just failed to pass into the secondary schools, and "this state of affairs has had a serious social consequence." We note that in the extracts from the Spens Report secondary education is covered by "grammar schools and technical high schools"—new names for secondary and technical schools. If snobbery must be pandered to, then why not improve matters by calling the latter technical colleges? However, this is not the industrial psychologist's approach, for his method is to base entrance on a series of vocational suitability tests.

"In work of the kind done by secondary school children at school and afterwards," says the author, "verbal ability is important; the type of work technical school children encounter calls less for this and more for *spatial judgment*." Being unable to decide on the meaning of the phrase "spatial judgment," we applied to the headquarters of the Institute of Industrial Psychology. Here a very courteous editor presented us with two more articles to study—very carefully connoted for ease of assimilation. One of these tells of the development of the Form Relations Test, and it appears that this may be used "to measure general intelligence and 'spatial judgment'—an ability which has been variously described as 'practical ability' and as an ability to form and use visual spacial images. It may also be used as a test of 'mechanical ability'; but the evidence so far adduced does not show whether mechanical ability is dependent on either, both or neither of the foregoing abilities."

This last phrase not being too helpful, we turned to an example of the "new Form Relations Test (to be called the Space Perception Test)," and whilst admitting its cleverness, we would point out that it suffers from exactly the same defect as the majority of such tests, and that is, the time factor is taken as the crucial evidence. Rapid visualisation provides no evidence of either quick decision or skilful execution of a job. For instance, a loam moulder may be good at visualising a finished mould from the blue prints, but his workmanship may leave much to be desired. In most tests, be they verbal or "spatial," much depends on the state of the faculties at the time of making the test and on luck. In a crossword puzzle, often used by the Americans as a vocational suitability test, some recent reading or a well-digested Shakespearian play gives an immediate start and creates the necessary mental attitude for a concentrated attack. Similarly with a jig-saw puzzle, the accidental contiguity of two correctly-fitting pieces may materially reduce the total time necessary for completing the puzzle.

We are somewhat sorry to state that, so far as we can see, the psychologists are still a long way from solving the problem of supplying industry with a basis upon which to select recruits, let alone the actual provision of large quantities of human material from which industry can make its own selection. The mind most likely to succeed in solving this problem is the type which has turned its attention for many years to the selling of cigarettes and cosmetics to the *hoi polloi*. They have successfully managed to create a *desire* for certain goods, and we see no fault in the logic that the instilling of a *desire* to enter industry is the proper method to popularise industrial recruitment. The suitability of those desiring to enter is of secondary consideration where initial enthusiasm exists, for this factor will, *per se*, do much to reduce misfits to a minimum. Under peacetime conditions, the Army had not too many "selling points" as a potential career for young men, yet the methods of recruitment were on a much higher plane than anything which has been evolved by industry. Moreover, in the Army Vocational Training Centre, suitability was secured by first arousing keen interest in the trades taught, then allowing the neophyte to choose a vocation, and after a short probationary period either confirming him in his choice, or switching on to another trade more suited to his general intelligence and manipulative skill. The after-life successes, of which a careful record was taken, showed well over 90 per cent., ascribable by those best qualified to judge as being due to initial interest generated and its maintenance during the period of training.

This second factor is the lesson which industry must learn, and an effort must be made to introduce those factors which make a university training so pleasurable. Athletics, clubs of various kinds, the Scout movement, and social activities are to-day the essential concomitants of a successful apprenticeship. Supplementary technical training should be easily available,

(*Continued on page* 68.)

Electric Furnace Design and Practice*

The design and practice of modern electric furnaces were discussed in a Paper by MR. H. F. WALTHER, presented at the Convention of the Association of Iron and Steel Engineers, held recently in Chicago. A brief summary of the Paper is appended.

Within the last three years the electric melting furnace has assumed a more prominent place in modern steel production than ever before. The demand for closer control in chemical analysis and physical requirements by the automotive and aircraft industries has played no small part in exerting pressure to expand the industry. Constantly, new uses are being found for the various types of stainless steels and many other complex types, the manufacture of which is possible only in the electric furnace. With the building of larger melting units the electric arc furnace has to a great extent been competing with the open-hearth process on a quality basis, though not on a production cost basis, in melting much steel in the simpler alloy types.

In investigating furnace construction and melting practices in the various plants, one is amazed at the various uses to which this most versatile of melting units may be applied. It may also be said that melting technique in producing the same types of steel differs somewhat with the various operators, in accordance with their concepts of the metallurgy of the process.

The electric melting furnace may be divided into three main classes: direct arc, indirect arc and induction. Each type has its place in ferrous or non-ferrous production, and the installations of all three are constantly growing in number.

The Paper discusses the direct arc furnace and related practices.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

"Dusty" Iron

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I am a moulder and my connections are with a small jobbing foundry making good-class iron castings for jig and tool engineers. Cast-iron stick is often called for, and it is cast vertically and run at the bottom. The moulds are made longer than the required length of stick, the extra length being used as a header which is filled with hot metal. The charges are 1 cwt. machine-cast pig-iron, 1 cwt. shop back scrap and 2 cwts. good machinery cast scrap.

Some 2-in. dia. by 18-in. sticks were recently cast and were machined into small gear wheels. The castings were definitely free from blow-holes or hard spots. The iron was slightly "open" but consistently so throughout. It cut, not in little chips as good iron should, but as dust, and the machinist complained that his cutting tools were quickly blunted. Although there was not one scrapper in 150 wheels, it was impossible to get a first-class finish on any of them.

There has recently been several isolated cases of castings machining "like dust." I should be glad if any of your readers could explain the reason for this, and how it might be overcome.—Yours, etc.,

V.M.

London.
January 23, 1941.

* "Iron and Steel Engineer."

The Recovery of Electric Lamp Caps

It is an important point in the national salvage campaign that the valuable brass which can be recovered from electric lamps should not be wasted, and especially that the caps should, whenever possible, be used again for their original purpose instead of being melted as scrap. These notes are provided for the guidance of those who are collecting and handling the caps with a view to their recovery.

The glass bulb or other parts of the lamp except the cap have no value for re-use. Therefore, to save bulk and weight in transport, it is preferable to remove most of the bulb and other parts before packing caps for return to the factory, and this can be done easily and safely by anyone provided with a pair of gloves, an old file, a barrel or other receptacle for the rubbish and suitable protection for the eyes. For the latter, a cheap pair of goggles will suffice, the only danger being the accidental entry of a small splinter of glass.

INDEX TO VOL. 63 NOW READY

The index to the editorial contents of Vol. 63 of the Journal (July to December, 1940) has now been printed. Readers wishing to receive a copy are asked to make early application to our Publishing Department, 3, Amersham Road, High Wycombe, Bucks.

The cap of each lamp to be disposed of should be grasped firmly in one hand, while the bulb is first sharply tapped with the sharp edge of a file to crack it and afterwards knocked off piecemeal reasonably close to the edge of the cap. Do not overdo this or one may damage the cap itself, which, if badly bruised or dented, cannot be re-used. It is not recommended that any attempt should be made to remove any part of the glass "foot" which protrudes from the inside of the cap, as the process is tedious, the amount of space saved small and the danger of damage to the cap considerable.

On no account should any attempt be made to remove the neck of the bulb or the cement which attaches it to the cap. This requires special means and also removes the support which will otherwise sustain the cap in its transit back to the factory and prevent it from being damaged by its neighbours. The solder on the cap contacts should also be left as it is.

Throughout the operation, all possible care should be taken to avoid denting or scratching the brass surfaces or cracking the black glass insulator which fills the butt end of the cap and carries the contacts. Caps treated in this way can safely be packed into barrels, wood or cardboard boxes (not sacks), of which the gross weight should preferably not exceed 2 cwts. per package, and returned to any branch of any member of the Electric Lamp Manufacturers' Association.

Notes from the Branches

Lancashire—The annual dinner, which was to have been held in Manchester on February 1, has been postponed to a later date.

Lincoln—A well-attended meeting of the Lincoln Section of the East Midlands Branch of the Institute of British Foundrymen was held on Saturday, January 18. This was the last of the series of informal social meetings for the discussion of "Wartime Problems in the Foundry." A full normal programme has been arranged for the remainder of the session.

Random Shots

Speaking at a "War Weapons Week" meeting, the local Member of Parliament raised a laugh by assuring his audience that the Abyssinians would not be likely to waste much money providing concentration camps for Italians.

* * *

Whilst on the subject of Italians, it is not given to every man to take part in the trouncing of the enemy in Libya, but a keen stamp collector told "Marksman" the other day that he had got quite a lot of pleasure out of finishing Italy off at home one evening. . . . Reflected glory is, after all, better than none at all.

* * *

Rationing with a Vengeance.

At a small restaurant the luncheon menu gave a choice of two dishes—steak and kidney pie or sausages. One customer, thinking the former sounded a little too wooden, chose the sausages, but soon he was heard complaining to the waitress.

"What sort of sausages do you call these, miss?" he asked plaintively.

"Grade C, I'm afraid, sir. They're all we can get now."

"C3, are they? I think they've called up the conscientious objectors by mistake," he replied sorrowfully.

* * *

In answering a "small advt." in the local paper, which read: "Very tame and affectionate lady's parrot for sale," one correspondent (who signed himself "Shy Bachelor") wrote that he regretted that he was not very interested in parrots, but would very much like to get in touch with the tame and affectionate lady.

* * *

TEACHER: Who can give me an example of a portmanteau word?

PUPIL: Blackguard, please, miss; being a mixture of a Blackshirt and an Ironguard.

TEACHER: Well, you may be right, but I should call that a synonym.

* * *

The same teacher asked for another example, and this time a girl suggested the word "flattic."

"That's one I have not heard before. What does it mean?" asked the teacher.

"Well, you see," explained the little girl, "since father joined up we've had to move up to the top of the house, and mother calls it our 'flattic.'"

"I see. In that case I should call that a euphemism," replied the teacher.

"MARKSMAN."

The Psychologist and Industrial Recruitment

(*Continued from page* 67.)

but not compulsory. Moreover, it should be made more attractive by such features as visits to works other than those at which the boys are employed. The works which will be most successful in their training of the boys will be those capable of not merely retaining initial interest, but of converting this to a glamour respecting future activities, much as is shown by boys serving in the R.A.F. to-day.

Thus, the problem for the psychologist as we see it is the countering of snobbishness; the creation of interest in the child mind to enter the practical side of industry; and ensuring means for not only maintaining that interest during the period of training, but deepening it.

Beneficial Effects of Zirconium in Cast Nickel-Silicon Bronzes*

By F. R. HENSEL, E. I. LARSEN and A. S. DOTY

The alloy under discussion is a nickel-silicon bronze and is one of many age-hardening or precipitation-hardening copper-base alloys. The hardening constituent is a nickel-silicon compound.[1] The quenching temperature necessary to produce hardening by a subsequent ageing treatment is a function of the composition and extends from about 700 to 950 deg. C.; the ageing temperature range extends from 400 to 600 deg. C.

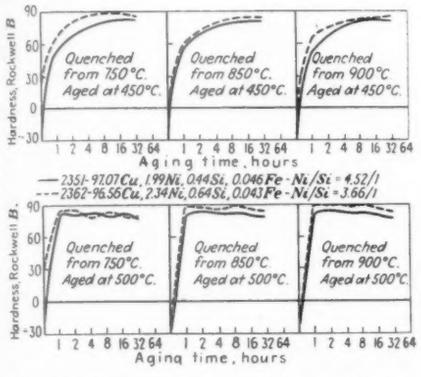

Hardness, Rockwell B
Quenched from 750°C. Aged at 450°C.
Quenched from 850°C. Aged at 450°C.
Quenched from 900°C. Aged at 450°C.
Aging time, hours
2351-97.07Cu, 1.99Ni, 0.44Si, 0.046Fe - Ni/Si = 4.52/1
2362-96.56Cu, 2.34Ni, 0.64Si, 0.043Fe - Ni/Si = 3.66/1
Quenched from 750°C. Aged at 500°C.
Quenched from 850°C. Aged at 500°C.
Quenched from 900°C. Aged at 500°C.

FIG. 1.—EFFECT OF QUENCHING AND AGEING TEMPERATURES ON HARDNESS OF TWO TYPICAL NI-SI BRONZES (2351 AND 2362).

Several foundries have spent years of active and intelligent effort in trying to control the casting and heat-treating variables of nickel-silicon bronzes and finally gave up the attempts because of the inconsistencies of results.[2] This undesirable characteristic was not manifest in the ultimate hardness or conductivity, but primarily in tensile strength and ductility, as shown in Table I. The variation in tensile properties was often much greater than that existing in the alloys of Table I. This table is shown because these eight test-bars were from successive heats of the alloy made under conditions duplicated as closely as possible by the best modern foundry practice. In some instances test-bars actually broke during machining.

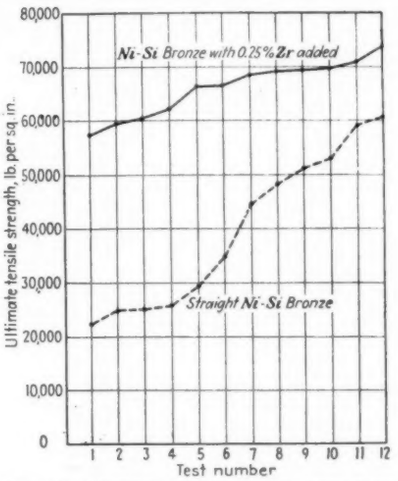


FIG. 2.—TENSILE STRENGTH OF TEST-BARS FROM FIRST 12 PRODUCTION HEATS WITH 0.25 PER CENT. ZR ADDED, COMPARED WITH 12 SUCCESSIVE HEATS OF NI-SI BRONZE.

FIG. 3.—STRAIGHT NI-SI BRONZE AFTER QUENCHING FROM 900 DEG. C. AND AGEING 16 HRS. AT 450 DEG. C. × 75.

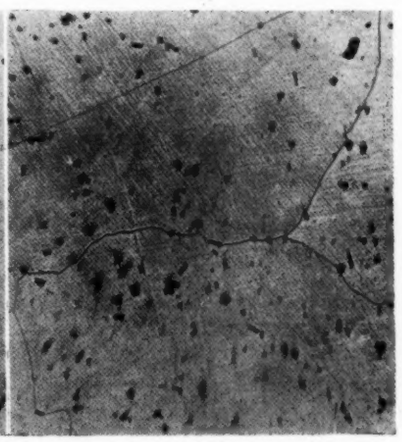


FIG. 4.—NI-SI BRONZE WITH 0.28 PER CENT. ZR AFTER SAME TREATMENT. × 75.

Note segregation in grain boundaries in Fig. 3, but in Fig 4, although some segregation is evident, it is not continuous, nor nearly as pronounced. Both samples were polished, then etched in $NH_4OH + H_2O_2$.

In an effort to trace the cause of the trouble, various melting and casting techniques were employed. The Ni-Si content was varied from 1.5 to 5 per cent. and the nickel-silicon ratio varied from 3 to 1 to 6.5 to 1. No appreciable advantage or disadvantage was noted. In order to eliminate the trouble, additions were made of magnesium, beryllium, cadmium, zinc, manganese, phosphorus, iron, lithium, titanium, thorium, uranium and zirconium. Most of the additions were below 0.25 per cent. Certain single tests, such as 0.25 per cent. Cd, 0.25 per cent. Mg, 0.25 per cent. Th and 0.1 per cent. Mn, indicated some improvement, but continued investigation of the alloys still showed inconsistencies in regard to tensile strength.

TABLE I.—*Characteristics of Cast Nickel-Silicon Bronzes.*

Specimen no.	Hardness, Rockwell B.	Electric conductivity. Per cent. I.A.C.S.	Tensile strength. Tons per sq. in.
2646 ..	91	39.2	10.63
2647 ..	89	40.1	13.05
2648 ..	91	39.7	10.63
2649 ..	90	39.7	22.85
2660 ..	94	38.0	20.45
2661 ..	96	37.7	21.52
2662 ..	89	38.6	17.28
2663 ..	90	38.3	9.73

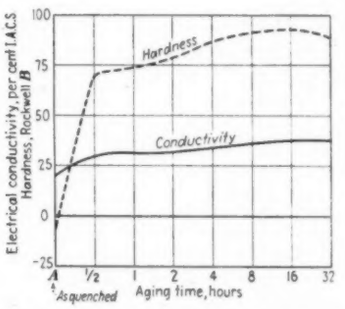


FIG. 5.—ELECTRICAL CONDUCTIVITY AND HARDNESS VERSUS AGEING TIME.

Sample L-894-A quenched from 900 deg. C., aged at 450 deg. C. Ni-Si bronze with 0.25 per cent. Zr added. Sand-cast. Conductivity sample ¼ in. dia. by 6 in. Hardness sample, 1 by 1 by ½ in.

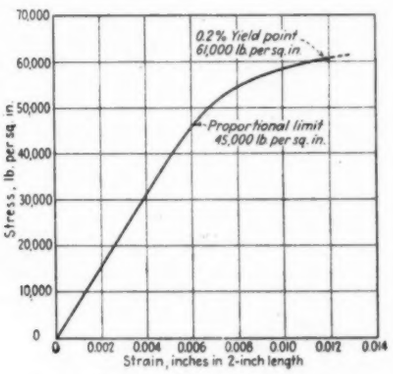


FIG. 6.—STRESS VERSUS STRAIN.

Ni-Si bronze with 0.25 per cent. Zr added. Sand-cast. Ultimate tensile strength, 30.6 tons per sq. in. Sample L-917-1.

The work carried out by the authors of this Paper was confined to cast alloys having compositions within the ranges of 1.5 to 3.00 per cent. Ni, 0.4 to 0.75 per cent. Si, balance copper.

Fig. 1 shows results of heat-treating tests on two typical nickel-silicon bronze castings of the type on which the observations were made. A quenching temperature of 750 deg. C. produces almost as high a hardness on subsequent ageing as do quenching temperatures of 850 and 900 deg. C.

Out of all the elements added in an attempt to improve the tensile strength of nickel-silicon bronze castings, zirconium alone gave consistently effective results. Test-bars from at least 20 successive production heats to which approximately 0.25 per cent. Zr was added showed no ultimate tensile strength below 25 tons per sq. in. The average was about 29 tons, and some tests showed over 31.25 tons. In comparison

(*Continued on page 78.*)

* Paper read before the American Institute of Mining and Metallurgical Engineers, and published in "Metals Technology." The authors are on the staff of P. R. Mallory & Company, Indianapolis.

A Turntable for Rapid Mould Production

BY JAS. TIMBRELL.

The production of rammed moulds by means of a turntable and Sandslinger, for split and flat-back patterns, is a suitable method for increasing output, as skilled finishing, coring-up and closing labour can be continuously employed in this capacity.

Fig. 1 shows a 6-ft. 6-in. turntable unit, set out with four types of standard interchangeable moulding boxes. The arrangement is adaptable and can be altered to suit various combinations and developments. The base and turntable are made in cast iron, and strickle boards and spindle will produce both these main castings. This method can be relied upon to yield castings sufficiently smooth and accurate without machining for the roller-ball channels. The top face should, of course, be machined level.

The 4-in. roller balls are cast in a permanent mould, as shown in Fig. 2. The inserted runner core will prevent the hot metal fusing to the permanent mould round the runner during pouring. The mould should be turned over, runner downwards, immediately the metal in the runner has set so as to ensure a true shape. Shrinkage will then take place centrally in the casting. To avoid distortion of the permanent mould, it should not be used repeatedly until it becomes red hot, but it should be allowed to cool off at intervals. If this precaution is taken, one permanent mould will yield the required number of roller balls for spacing at about 18-in. centres.

All patterns are worked "loose" from the previously inserted dowels and holes, which are numbered to register and to ensure that the patterns re-occupy their predetermined positions. The dowel holes are drilled through the table and arranged so as not to foul the roller-ball channel. Provision is also made to lift the table for sand removal when necessary by a centre eye-bolt.

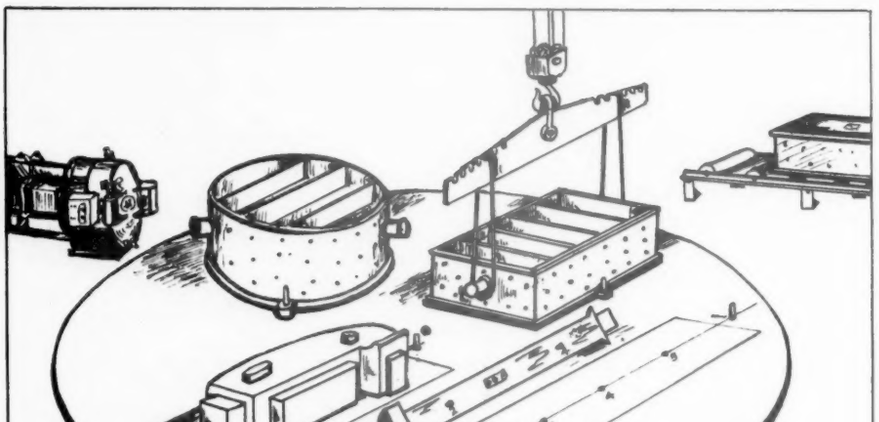
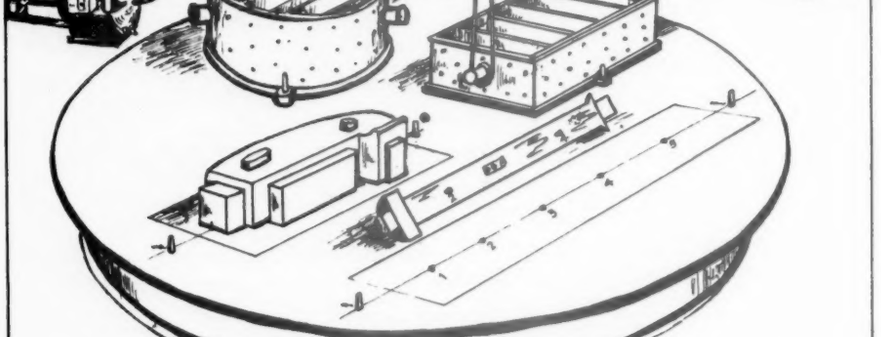


Fig 1.



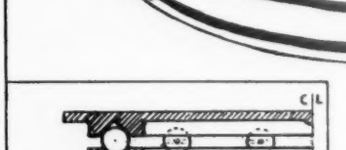


FIG.2

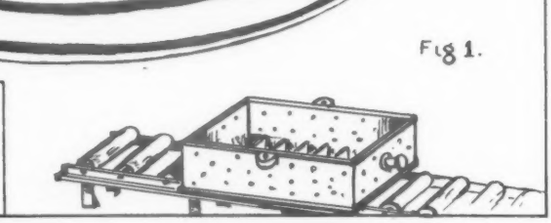


FIG.3.

Fig. 3 shows the holed bottom plates carrying two runner bars to ensure easy movement on the mould conveyor, and additionally the four lugs for use with loose handles for lifting into place. This sketch also illustrates how existing boxes were made to conform to the standard by the addition of bolted-on pin-hole lugs and roll-over trunnions. The boxes are drilled to take the type of plate-holding clamps illustrated, which are standard for the whole range of moulding boxes in use on the table. Generous working space should be planned round the unit, for returned patterns, lifters and the general details associated with the cycle of operations.

Scrap Usage Essential

BY "ONLOOKER."

In connection with America's copper needs for this year it has been pointed out that there will be a return to the fabricators of brass and copper semis in the shape of process scrap from their customers, this being in point of fact a not inconsiderable contribution to the supply problem. This naturally applies only to business done in the United States, for if these semis are shipped overseas the chances of the process scrap being returned are so remote as to be unworthy of consideration. In the last war, for example, thousands of tons of brass fuse rod were sold to Britain for fabrication in this country, and the swarf which resulted from the machining operations here presented a disposal problem which eventually received the attention of the Ministry of Munitions.

On this occasion matters are different, but it is quite possible that some of the material crossing the Atlantic is in a form which would normally yield process scrap for return to the mills and must in the circumstances be debited to stock account on the basis of 100 per cent. outgoing. America's loss is our gain as far as supplies of metal are concerned, but one has to remember that dollars must be found to pay for the full weight of material shipped to this country, and from that point of view the transaction is perhaps not quite so favourable.

The same idea applies to transactions in the United Kingdom, and it is a recognised custom of the trade that when a metal roller, for example, supplies brass or copper strip to a customer for blanking, the resultant webbing scrap as it is called shall be returned for credit at an agreed price. One obvious advantage of this plan is that the rolling mills take into consideration the amount of fabricating waste when obtaining the necessary raw material, and by employing metal produced within these shores shipping space is saved. This is accepted practice in the trade and is fully understood by the Controllers of Non-ferrous Metals, who grant licences accordingly; but what is not so straightforward is the estimation of how much outside scrap, genuine secondary metal, can and ought to be consumed by manufacturers in lieu of virgin metals.

Narrowed Price Margin

Obviously the intensive use of all home-produced metal is of paramount importance at the present time, when shipping space is so valuable. Generally speaking, the use of scrap is governed by whether or not consumers are able to obtain what they want at prices relatively favourable in comparison with the cost of virgin metals, and unless the margin is sufficiently favourable activity in old metals lags.

Many people feel that the maximum values for scrap permitted under the Order are too generous to the sellers, for the buyer has to pay carriage, handling, etc., and probably commission into the bargain, all perfectly legitimate charges, but the net result is that when the final invoice is rendered there is not much difference between the charge for the scrap and that for virgin metal. It will be said that the figures quoted in the Ministry of Supply Order are maxima and that the buyer can easily refuse to pay a price which does not seem to him fair.

This would appear, however, to be a counsel of perfection, at any rate in existing circumstances, for those who have first-class scrap to sell find in practice that they can get their price, and that price is the maximum. The position with the cheaper types of scrap is rather different, and here one finds that the maximum price permissible is not always obtainable, owing mainly to the fact that supply exceeds demand, with manufacturers apparently able to get all the virgin metal they want.

French Views on Moulding Sands

Extract from a lecture course given at the Paris Foundry School, translated by J. McLure Renwick, and reprinted from "Engineer and Foundryman."

To-day, more than ever, the question of sand treatment has come into prominence, because it is realised that, with an intimate knowledge of the sands used, the moulder can with greater assurance produce good castings. Instruments are in daily use which determine the bond, permeability, moisture, crushing strength, etc., of sands, and these are essential to the foundryman who wishes to work along the best lines. However, the principal criticism which might be made with regard to these tests is that sufficient attention is not given to the original state of the sands before using them and when they come to the foundry in the natural state.

Many sands have a good bond and a permeability exceedingly sensitive to treatment in the wet state, and for the most part these properties show up very clearly if allowed to temper after humidifying the sand (imbibition of bond).

With rare exceptions new sand is seldom used in the foundry; the new sand is usually added in variable proportions to sand which has already been used, and these mixtures receive a treatment or preparation before being re-employed. That being so, the question to be solved can be put into three wide categories.

(1) Determine the necessary mixtures required for a particular product, as much from the point of view of the composition of these mixtures as of the method of preparation.

(2) Establish a control to ensure the regular nature of the sands to be supplied for the preparation of these mixtures.

(3) Establish a control of the prepared mixtures, in order to ensure regularity of the moulding operation and the consistence of their properties.

Determining the Mixtures for Moulding Composition

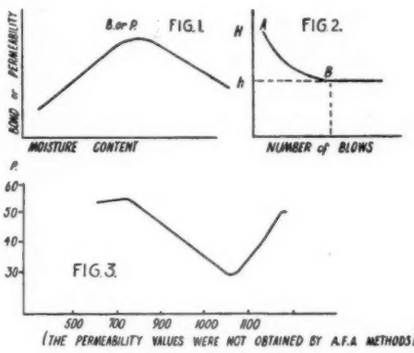
The character of this work varies a little according to whether it is simply a case of determining the best use to which the new sand can be put, and which already gives empirically results which appear satisfactory, or whether it is to find yet another new sand. The first aspect of the problem is found very frequently in practice, and remains to be dealt with by many more foundries.

The cycle of operations made by the sand in a particular manufacture starts with the mixtures coming from the sand plant to be re-used for moulding. They must have certain degrees of bond and permeability if the castings are to be good (degrees which, however, vary from one foundry to another). During and after the pouring, the high temperature of the layer of sand in contact with the metal produces a rapid drying and even burning of the bond, and at the same time certain grains burst and are pulverised. There is therefore in the sand employed for the mould a partial destruction of the bond, and an increase in the percentage of inert silt. If, then, this sand were sent back direct to the sand plant, the result would be a sand decreased in bond and with a reduced permeability, evidently variable according to the kind of work being performed and the nature of the sand.

One could avoid the deterioration of the properties of the sand if it were possible to remove the deteriorated bond and the silt from the grains. This is not practicable except in very special cases (desilting and washing), so it is generally the practice to add to the sand at each return to the sand mill a certain quantity of new sand, which gives to the heap sand, new active bond and grains which are intact, and from which comes improvement in the bond and the permeability; in other words, a dilution is made of the parts destroyed.

Maintaining a Constant

It is evident that, for a given type of manufacture, *i.e.*, a given reaction on the sand used for the moulding, there must exist, if the results are to remain good, a sort of equilibrium by which the composition of the mixture (proportion of new sand added) and the method of preparation by the sand plant would cause the bond and permeability values to remain constant at each cycle of utilisation. It is here, in the search for this equilibrium and the conditions necessary to it, that the problem of the determination of the mixtures is to be found. This problem, as far as it concerns the preparation of a certain sand already chosen to be incorporated at each passage of the old sand to the sand plant, is inseparable from the problem



of the control of the mixtures which is discussed later.

It is evident, in effect, that the more this operation is made efficacious in raising the bond and permeability, the more the proportion of new sand to be added may become reduced. These points are dealt with later.

Concerning the other aspect of the problem with regard to the composition of the mixtures—that of choosing the new sand—matters become more complex. This problem presents itself in practice in two ways; either the sand employed for a certain type of manufacture does not give satisfaction, even after everything has been tried in the matter of the composition of the mixture and its preparation (persistence of certain drawbacks), and one tries to obtain a better; or trying out another new sand to replace a sand already employed with success up till now, but which has become unobtainable or too expensive, etc., or when one is trying to obtain a sand as close as possible in composition to the original. In such cases one possesses a base for good comparisons, and it becomes necessary to separate the characteristics. This is a delicate matter, and it has been tried in many foundries by empirical methods determined according to appearances or to methods known to be employed in other foundries. This is a risky method and will lead to great troubles, not at once, but weeks or even months after the initial tests, when the whole mass of sand in circulation has become profoundly modified in a manner quite unthought of initially. It is therefore important, in order to avoid such serious incidents, to obtain an idea in advance of how the sands will behave in service, that is to try to determine what one might call the "utility tests." The laboratory tests will show up the particular features of certain sands, and if they do not actually give absolute "utility tests," at least they indicate important factors for appreciation. Here are a few:—

Variation of Permeability and Cohesion in Relation to Water Content

When curves such as Fig. 1 are traced for moisture content, varying, for example, between 3 and 10 or 12 per cent., one obtains in most cases curves presenting a maximum for a certain moisture content. When the sand is too dry, it has no body, and the silt as well as the dry binder closes the pores and the permeability is low. When the sand is too wet, there is no bond, for the sand has become muddy, and, the pores being filled with water, the permeability is weak. These two cases prove that some values are obtainable between these extremes. The angles of the components of the curves, and their form, *i.e.*, having more or less a peak or even a flat in the region of the maximum, give a very interesting idea of the susceptibility of the sand to humidity, which is a very important matter in practice. Another important matter to be observed concerns the relative position of the maximum B and P (bond and permeability) of the same sand from the point of view of moisture. Three cases may present themselves: (*a*) B and P curves correspond at the same moisture content; (*b*) B corresponds to a moisture content less than P; and (*c*) P corresponds to a moisture content less than B.

As the sands are used by the moulders with a water content which corresponds—empirically or otherwise—to their maximum bond only from the point of view of ease in working, the first case is in principle the most advantageous.

One can now observe the values of the moisture content corresponding to bond and permeability (bond particularly, for the reason given), for the weaker the sands are the less they serve for green-sand moulding. Many tests have been made to connect up the different cases, *a*, *b* and *c* to the peculiarities of the granulometric composition, and, for example, to the proportion of the smallest grains (silt). It would appear that there is a qualitative relation between them. It is possible that some development of a perfected granulometric method of analysis will permit in the future of postulating the matter scientifically and revealing the cause of the irregularity which one notes in the curve of certain sands.

Compression

In practice, when testing for permeability, a test-piece is made to a predetermined final volume, but it is found that there are great differences in the compressibility of sands, and that for the same sample the compression may vary considerably according to the moisture content.

It is easy, after having measured the permeability of a test-piece, squeezed up under usual conditions, to place it again in the apparatus and continue to compress it by supplementary blows, noting the decrease in the initial height H (Fig. 2). This is continued until the maximum squeeze is obtained, that is until no further appreciable decrease in the height H is noted. The curve obtained falls rather quickly to the abscissa from A, and finishes at more or less the height *h*. The form of the curve from A to B (maximum squeeze) gives a good idea of the compression to be obtained with relation to moisture content. The test could be usefully completed by measuring the permeability corresponding to the condition at B (permeability calculated on taking note of the value of *h* in the test-piece). It is highly probable that in practice the aptitude of the sand to give

"scabbing" may be linked up with the permeability at maximum squeeze and to its variation in terms of moisture content.

The foregoing tests, made on new sands, might cause one to ask what would be the value of these various tests (susceptibility to moisture, squeezes, etc.), when in practice this new sand only forms but a part, more or less important, in the mixtures employed for moulding. Comparative studies which have been made in various foundries have shown that the old sands coming from the progressively used sands in service of new known sands retain with these a hereditary resemblance with regard to the characteristics mentioned. In other words, the various curves retain qualitatively the same form, only their position changing.

It is possible, however, artificially to age a sand required for a particular job by subjecting it to drying. The necessary temperature and duration of heating depend naturally on the nature of the work. For such work as green-sand moulds for grey iron, the temperature for drying is usually about 450 deg. C. and the duration two hours. It is interesting, after having subjected the new sand to this treatment, and after cooling and humidifying, to trace out the curves for bond and permeability/moisture content. In many cases the same curves are found, but with lower maxima, and corresponding to higher water content. Nothing prevents one eventually from repeating these tests with more energetic drying conditions to obtain a more exact idea of the probable life of the sand in service, and the percentage of new sand necessary to revivify it at each return from service. Tests of this nature are sometimes called the "life tests" and would prove useful in showing up the special properties of certain sands which in their new state appear to be comparable to others.

All these methods of investigation could be applied with profit, as well as many others, on new sands in the laboratory, in order to acquire some knowledge in advance of the chances they have of giving satisfaction in one manufacture or another, and to determine the differences between them and sands already used and of which the qualities are known.

Another point which is rather obscure concerns the influence which a sand may have on the skin of castings, and the facility of removing the sand on fettling. Certain sands show a definite superiority over others in this respect, and the causes have not yet been determined in the case of grey iron and non-ferrous alloys.

To conclude, in order to resolve certain problems, one could be led to try out special tests, and here is an example. A natural clay-bonded sand had for some reason been substituted for another in a steel foundry making medium-sized castings in green sand. Precautions had been taken to ensure that the new sand had bond and permeability at least comparable to the old sand. In spite of this, the first day's service proved, from faults in the castings, that there was a lack of permeability at some moment during the pouring, which fact leads one to suppose that this property suffered some modification at high temperatures. A series of test-pieces was prepared for permeability, and they were heated to different temperatures in a laboratory oven, taking the necessary precautions to avoid any disintegration.

After cooling, the permeability test was made at room temperature, and the results from the samples subjected to various temperatures were traced (Fig. 3). Supposing, which is highly probable, that the physical chemical modifications which were produced at the higher temperatures were not reversible, and that their effect on the permeability remains after cooling, then one notices that this property diminishes very considerably through a certain interval in the temperature, and rises quickly again.

The explanation of this phenomenon has been recognised when examining how small particles of sand (silt and binder) behave together when heated and separated for test by granulometric analysis. In heating to various temperatures, pyramids are formed composed solely of these particles, and it has been found that between 900 and 1,050 deg. C. there was a swelling, a closing up, a blowing and an emission of gas. The gas emission occurred at 1,050 deg. and the particles disintegrating took up a volume somewhat less than the initial volume. Ever since, the foundry in which these tests were carried out has made it a routine matter to study the behaviour during the disintegration of the bond of the sand used for steel castings, and has been able to establish a series of interesting correlations.

Preparation of Sand

Essentially the preparation of moulding sand mixtures consists of two actions: (1) to enrobe the grains and little particles which cannot be eliminated with a coating of bond, and (2) aerate the sand in such manner that it will take an even squeeze from a uniform effort.

Only the first action will be dealt with, for the second depends merely on the question of choice of material. It is a well-known fact that the proper preparation of a mixture improves its properties in service when cold, and also afterwards, when hot; to arrange for this is, therefore, just as important as the composition itself. In the layout of a foundry the mills which might be used may vary very little. The question is therefore—how should one use the mill at disposal for a given sand? There exist in practice two methods by which one

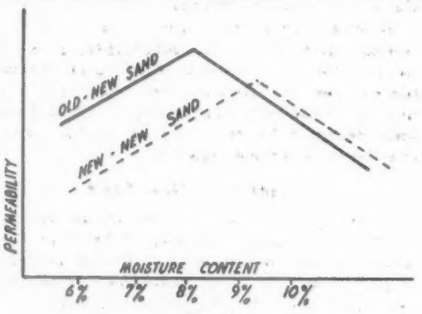


FIG. 4.

tries to obtain the first action mentioned—one consists of mixing and stirring up the new sand with the old in the dry state, and to add the necessary water to the mixture after treatment; the other consists of subjecting the sand to a rubbing action in order to obtain the repartition desired. It is needless to point out the inferiority of the first idea, which only gives a simple mixing and no repartition, and which, in view of the condition in which the operations are made, risks altering the bond, since one is never certain that this will imbibe all its water after the initial drying, and consequently of obtaining the desired plasticity.

This method is nevertheless sometimes employed in a partial way (only the new sand being dried), but sometimes completely in certain continuous treatment plants. New sands vary in strength and are often classified in categories. Though the strong sands may appear to have body, it does not always signify any pre-determined proportion of bond, because the natural repartition of the bond varies very considerably from one sand to another, and evidently influences the strength. Certain sands in particular present a very bad natural repartition, and one finds in the mass more or less plastic nodules of clay, which render its incorporation into the old sand very difficult. It sometimes happens that when one attempts rubbing the new sand into the old by the wet method, the dry dust in the old sand gets mixed into these nodules, giving them a consistency not unlike rubber, and preventing them from breaking up and distributing themselves around the grains.

Effect of Drying

In some foundries it is a custom to dry such new sands, when the nodules break up into dust and disintegrate, rendering their incorporation possible. The drying would offer no very great inconvenience if it were properly done, and if one could be sure that the sands so dealt with did not suffer from this treatment, but the great difficulty is to obtain an even drying, and one risks removing the chemically combined water. It is quite possible that for such sands a method of incorporation by the wet method can be found, thereby eliminating the risks of burning during drying, and profiting from the advantages mentioned later. Admitting that it is desirable to dry certain new sands to mix them with the old, the humidifying of the sand should be done before the rubbing treatment, and not after, for it is inadmissible that the rubbing could be done with success by the dry method, inasmuch as this work is often effected in mills which more or less resemble grinding machines.

There are various reasons why the rubbing should be done by the wet method. First of all (exception made for very special reasons, such as for rock sand) one must never crush the grains, and this is exactly what does happen even in a mill with rubbing mullers, when the sand is dry and there is not sufficient sand on the table, and how much more therefore on a pan mill. Again, if the bond has to be rubbed around the grain, it must be in the plastic state, in other words moist, and the more it is moist the better will the incorporation be done.

Effect of Milling

Again, it is common knowledge that, if a clay is kneaded in the wet state, its plasticity increases, a further good reason for the employment of the wet method. These considerations show what influence the amount of water has to bear on the preparation. When one studies the variation of the permeability and the bond in a mixture with regard to the duration of rubbing in a machine, using large mullers for instance, it is found that at the beginning of the operation there is a decrease in the permeability due to the fragmentation of the grains, but this property begins to increase, as well as the bond, to attain at the end of a certain time a limited permeability, which cannot be increased no matter how long the rubbing continues. This reduction of permeability at the beginning of the treatment only goes to prove the danger of treating the sand when the grains are not protected by their coat of bond, or at least the interest there is in protecting the grains as early as possible in the process, *i.e.*, to have the bond in a very plastic condition.

If curves as before are made, varying the moisture content, one will find that for many sands the decrease of permeability at the beginning of the process is very slight, and even eliminated altogether by the high water content, and also that the maximum values of permeability and bond are obtained very much more quickly. This latter finding is of great importance if one reflects that in practice the time of rubbing on the table is somewhat reduced because of the necessity to produce quantity.

Permeability and Water Control

Taking things a little further, one often has the sand treated with an exaggerated water content, then leaving the sand to dry a little before using it. This is found particularly with sands which in their natural state give the maximum in bond and permeability in relation to high water content. The following experiment can with advantage be cited. Three

parts of the same mixture were treated absolutely identically, but with different water contents, *i.e.*, 5, 7 and 9 per cent. After leaving the sand mill, the water contents were levelled to 7 per cent.; the sand with 5 per cent. moisture had a further 2 per cent. added to it, and the heap with 9 per cent. was spread out and left in contact with the air for a sufficiently long time. The permeability and bond values were found to differ, and it was proved that the heap which had been treated with 9 per cent. water showed values of 25 to 30 per cent. above the others. This case is probably not general, but its existence only goes to underline the interest one has in studying all these questions when deciding the matter of preparations.

Other points might be mentioned with regard to the moisture content. It has already been mentioned that certain sands possess nodules of clay in their mass. One can break these and spread them around the grains by rubbing in the mill, during a preliminary operation on new damp sand only, and by adding, if necessary, a little more water. Once the even distribution of the clay has been effected in the new sand, the old sand can be added and the incorporation effected under the best conditions, when it will be found that the clay lumps have completely disappeared from the final product.

Sometimes a clay mixture addition has been added. In one particular case a steel foundry desired to add a very refractory clay to increase the body of the sand and the refractory nature of the bond. Only very poor results were obtained when this quality of clay was merely added to the sand mill. When, however, a heavy liquid clay mixture was prepared 24 hrs. in advance, with as much water as the clay would absorb, and given the time mentioned to do so and then added to the mill, it was found that only half of the clay was required to obtain the same body as in the first case. With regard to its influence on the refractory nature of the sand, this was only manifested in the second test.

Time Factors

The importance of noting the time between damping and using certain mixtures should not be neglected. In the light of what has been said, one ought to try to establish some data with regard to the sand rubbing of any determined mixture, with the idea of arriving at the highest possible values of permeability and bond, and with the rubbing time compatible with the necessities of production required.

Regarding the type of mill to be used, this is a matter in which the choice is not very large. Where large production is required, the mills with mullers gliding on the sand actuated by the table are the most desirable, particularly if the mullers are as long as possible. The mill with a very deep pan, where the sand is mixed by means of elbow ploughs, is rarely satisfactory, for there is merely a mixing and not complete incorporation.

Having a mill with large mullers and certain fixed characteristics such as muller weights, length, speed of table or pan, three factors can be linked up together to be investigated: (1) thickness of sand on the table; (2) rubbing time, and (3) moisture content.

The thickness of sand plays an important role in relation to the rubbing of the grains (and is in relation to the humidity) and to the duration of rubbing.

The rubbing time is in relation to the moisture content, and determines with the thickness of the sand the production of the mill. As for the humidity or treatment by the wet method, its importance has already been shown.

It is interesting, in accordance with current practice, to fix the rubbing time and humidity in order to determine the amount of sand to allow for on the table. This of course is determined evidently in conjunction with the permeability and bond. Curves are then made showing the variation of the sand properties in accordance with the rubbing times. The water content is then studied. One has now sufficient and precise indications to fix the rubbing conditions.

It is seen at once from the above that it is not a question of establishing a regular system, since the factors linked up together are continually being varied; it is merely a rough and ready method, though a very fruitful one, to seek some sound practical application.

With regard to the moisture content, one may ask if it is necessary to try out so many different values. Experience shows that the most advantageous value, in general, is between those which correspond to the maximum bond of the new sand and the maximum bond of the old sand coming into a mixture. According to the difference between these two values, one can make one or two trials, allowing the option of trying yet another outside of the difference, to decide whether or not one has found the most frequent occurrences. These tests are made evident by tracing each time the curves of the various properties against rubbing time. It is as well to repeat the curve of a given moisture content by doing the humidifying 24 or even 48 hrs. in advance, to see what data this factor would give.

As this determination accompanies for the most part that of the composition of the mixture, the previous curves are repeated for various preparations of new sand, and then one possesses all the elements for deciding the fundamental basis which has the greatest chance of giving the best results in practice.

Whether these tests are carried out in the foundry itself or in the laboratory, it is much more convenient to be able to make the water content test by means other than the drying method; different reliable rapid methods have been designed for this purpose, and are obtainable from reputable makers.

Control of New Sand

In order to obtain the desired continuity of results in foundry practice, it becomes necessary that the new sands should be controlled, with the idea of recording variations which they may present, and before having to wait until the amount of wasters in castings draws the attention. The layers of sand in a quarry are rarely uniform and homogeneous, but one might suppose, apart from slight differences in the chemical analyses and above all granulometric, the sand extracted being of the same geological origin should have the same details of intimate constitution more or less constant. It is unfortunately not always so, and though the question has not been closely studied, there are such differences, as the following example proves.

A sand employed in a steel foundry gave quite good results, when suddenly it was found, after a new delivery, that faults became apparent in the castings. A chemical and physical analysis revealed no difference from the previous sand employed, but a study of the variation in the permeability with moisture content brought to light a very great difference, as the curves in Fig. 4 show.

The curves are absolutely identical as to form, but were displaced horizontally corresponding to some 2 per cent. moisture content. As the preparation was made with about 7 per cent. water content, the difference in permeability was considerable, and this decrease was a direct cause of the defects observed in the castings made from the new sand. The mixture preparations were made afresh, resulting in the re-establishment of the dotted line to a point where, with 7 per cent. water content, the permeability was sufficient, and the faults then disappeared. The cause of the difference in the two sands was never found out, but had it been known that this difference existed before the sand was used it would have obviated the necessity of having to scrap certain castings.

This all goes to show the interest and the profit to be obtained by using the "utility test" for new sand. Among the tests mentioned, a few could be used, for it would be too onerous to employ all, but the few used should be correlated to facilitate the work.

Control of Prepared Sand

In large foundries where the sand treatment is often done by a separate department, the moulding shop can rapidly control the regularity of the prepared mixtures sent to them by simple tests for moisture, permeability and bond. There is every chance that, if the values are within the limits fixed, the preparations they represent will possess the same qualities as those previously employed for a particular manufacture.

Thermal Relations between Ingot and Mould

In a Paper on "The Thermal Relations between Ingot and Mould," prepared for presentation to the Iron and Steel Institute as Paper No. 4/1940 of the Committee on the Heterogeneity of Steel Ingots, and submitted by the Stresses in Moulds Panel of the Ingot Moulds Sub-Committee, the author, MR. T. F. RUSSELL, has summarised his work in the following terms:—

Saitô's formulæ for the distribution of heat between ingot and mould are examined quantitatively. The practical variations from the ideal case are discussed, and it is thought that the possibility of deriving more exact formulæ than Saitô's is very remote.

Examples are worked out for circular and square ingots of the same cross-sectional area cast into moulds of four different thicknesses. Curves are drawn showing the temperature at different points in the ingot and moulds, the temperature distribution across a diameter and the total quantities of heat in the ingot and mould at different times. Curves are also drawn to show the effect of "mould ratio" on the temperature cycle occurring in the ingot near to the mould wall and on the time taken for the temperature at the centre of an ingot to fall certain amounts representing solidification. The latter show that solidification is accelerated by increasing the mould thickness until the mould ratio is about 0.8 to 1.0, but that further increase in mould thickness has an inappreciable effect.

Four sets of experimental results on the measurement of mould temperature are examined, and they show that the greatest difference between theory and practice is found at positions in the mould near to the inner face. This is attributed to the effect of the air-gap forming between the ingot and the mould.

Alloys of Tantalum

Discussing the physical and chemical properties of tantalum in the "Canadian Mining Journal," L. SANDERSON indicates that the alloying of tantalum with other metals is quite feasible. The principal alloys are tantalum-iron, tungsten-tantalum and tungsten-molybdenum. Ferro-tantalum (70 per cent. tantalum), to which some niobium has been added, is used to a certain degree in steel manufacture as an alloy designed to confer hardness. While it increases the elastic limit and breaking strength of the steel, it shows as a cutting alloy tool steel no superiority over the tungsten high-speed steels, while costing more. Its use as a corrosion-resisting metal when alloyed with iron has been known, but has not developed because of the lower cost and greater applicability of the rustless irons and steels.

Casting of D.T.D.424 Alloy

SOME PRACTICAL ADVICE

In view of the difficulties which have been experienced in some quarters in using alloy D.T.D.424 in substitution for other alloys, particularly L.33, some practical notes have been compiled by the Technical Committee of the Light Metal Founders' Association, and we are indebted to that body for permission to publish them.

Sand Casting

In the sand foundry D.T.D.424 gives little trouble and requires very little in the way of special technique. Generally speaking any mould that is suitable for "Y" alloy will be quite satisfactory for D.T.D.424. In using D.T.D.424 as an alternative to L.33, allowance must be made for its higher contraction.

Gravity Die-Casting

Experience in substituting D.T.D.424 in place of L.33 for die-castings has shown that, in practice, three types of defects arise: (1) Surface shrinkage, in some cases very pronounced; (2) cracking; and (3) misruns.

With high-silicon alloys, the die-casting pouring temperature is not critical, it being feasible to pour castings at a high temperature without running into trouble. Many thin-walled and complicated castings are only possible on this account; but it must be emphasised that this procedure is out of the question when dealing with D.T.D.424, otherwise serious cracking may ensue. About 730 to 740 deg. C. may normally be regarded as a maximum. If misrunning is experienced, steps should be taken to keep the die hotter, and perhaps to use a heavier coating and provide more numerous vents.

Maintaining Die Temperature

Attention to the following two points will help to keep up the temperature of the die:—

(*a*) The die should come apart easily and quickly, *i.e.*, there should be no tight dowel pins, cores or slides, and the casting form should be properly tapered and smoothly finished. Clamping arrangements should be quick and efficient; the separate "C" type of screw clamp used in some foundries is undesirable from this point of view. Mechanical ejection, where possible, is very desirable.

(*b*) The operators should work rapidly and lose no time between casts. As soon as the casting is set sufficiently solid to be removed without damage it should be removed, and another one poured with the least delay possible.

(*c*) Additional heat from gas burners, or torches, may often be employed with advantage, such burners being in continuous operation. Cores, and other portable sections of the die, may also need placing on a furnace plate, or in a gas flame as soon as they are taken apart, and left until re-assembled.

(*d*) An extra riser or two is sometimes useful, over and above those necessary for making the casting and feeding it, in order to assist in keeping the die hot by reason of the greater amount of metal poured in.

Runners and Risers

Runners and risers proper—that is, those actually required for making and feeding the casting, need proportioning on more massive lines for D.T.D.424 than for L.33 and although every job, naturally, must be considered on its merits, it may be said that, speaking generally, an increase in cross-section of from 50 to 100 per cent. will probably be required in the runners, etc., with a corresponding increase in gate openings. Bosses and other heavy sections should, whenever convenient, be provided with their own risers.

In many cases, particularly where simple castings of uniform section are concerned, the die designer, taking full advantage of the fluidity and freedom from cracking characteristic of silicon alloy, uses a quite short and narrow runner and small gate—in effect, little more than a slit running down from the top of the die to the highest point of the casting impression. Such a pouring layout is useless for any other aluminium alloy, and if a die of this description has to be used for D.T.D.424 it becomes essential to cut entirely new runners of greater capacity and more logically disposed, leaving the original one to act simply as a vent.

Apart from the placing of runners, etc., there are certain other aspects of die design that need consideration. In the interests of heat conservation, especially of small dies, it is wise to keep the walls of the mould as thin as possible, consistent with strength, if it be required for use with D.T.D.424 alloy. Existing dies can usually be thinned down by machining away surplus iron from the exterior, and cores can be lightened by boring out, or drilling a series of holes. Separate chills, similar in formation to cores, are often necessary on isolated bosses to take care of any shrinkage which cannot be quite eliminated by the removal of coatings. These chills may either just cover the large faces of the bosses or else completely surround them and they should be removed at each cast to be cooled down in water or a graphite wash.

Castings embodying widely spaced webs, ribs, or bosses are frequently made successfully in L.33 from dies wherein the form is simply sunk in, without any provision being made to relieve contraction strain between the lugs, etc. Such procedure is impracticable with D.T.D.424 on account of the pronounced hot-shortness of this alloy. Hot-shortness cracks may in many such cases be avoided by incorporating withdrawable slides placed so as to form the inner faces of the lugs, *i.e.*, on the sides where contraction comes into play.

In short, it may be taken that a die designed so as to function satisfactorily with "Y" alloy will be entirely suitable for use with D.T.D.424.

Die Modifications

There are certain components which can only be made as die-castings by taking full advantage of the characteristics peculiar to L.33. In these cases no other alloy can be successfully substituted. Certain other items may necessitate complete new dies before the use of D.T.D.424 becomes feasible; but in a large number of cases the necessary modifications can be carried out in existing dies or by the replacement of one or two parts.

Particularly is this so in the case of dies where the casting impression is contained entirely in the base block, and the runner and risers are formed by the die sides fitting round a main core and resting on the base. If the runner and risers are found to be inadequate and insufficient material is available for increasing them, then they can be effectively replaced quickly and cheaply.

In cases where it is found impossible to produce good castings in D.T.D.424, some modification in the design of the component may provide a remedy—generally by increasing thickness of section. Some very thin castings of large surface area may need to be thickened up all over, perhaps by as much as 50 per cent., in order to avoid misruns. Cracks will be minimised by increasing draft and by enlarging all fillets, and in most cases improvement will result if heavy bosses can be lightened by coring through holes. This has the effect of reducing the volume to be fed, with a consequent reduction in liability to sinks.

The production of satisfactory die-castings in D.T.D.424 alloy should present no difficulty to those experienced in the use of "Y" alloy or other alloys with similar foundry characteristics. The chief items to be borne in mind in changing over from L.33 alloy are:—(1) To ensure ample feeding; (2) to use a moderate pouring temperature; and (3) to keep the die hot.

Corrosion of Aluminium Sheet

A Paper by J. M. BRYAN and T. N. MORRIS in the Journal of the Society of Chemistry, entitled "The Corrosion of Different Grades of Aluminium Sheet by Weak Acid-Salt Solutions and by an Alkaline Citrate-Phosphate Buffer Solution in the Presence and Absence of Oxygen," is part of a programme of research designed to provide information of practical value in connection with the service of aluminium plant and equipment used in the food industry and to add to the general scientific knowledge of the corrosion of aluminium. It is shown that, in the absence of oxygen, acid brines containing 0.5 per cent. of citric acid and 0.2 and 2.0 per cent. of sodium chloride behave like a plain 0.5 per cent. solution of citric acid in that they do not attack either pure or commercial grades of aluminium at 25 deg. In the presence of oxygen, however, whereas the plain acid is still without corrosive effect at 25 deg., the acid brines are corrosive. With 2.0 per cent. of sodium chloride present, corrosion increases with decrease in the purity of aluminium, and this is due to the effect of the impurities in promoting the breakdown of the protective film and general corrosion. Film protection is greatest with the purest grade of aluminium (99.992 per cent.), but in this case there is danger of localised action and pitting. With 0.2 per cent. of sodium chloride present, the film is more protective and corrosion is less than with the more concentrated solution. There is, however, a greater danger of localised action and pitting of all the grades of aluminium tested. The rate of corrosion of aluminium by an alkaline buffered solution of *p*H 10.78 is rapid, but decreases with increase in the purity of the metal, although in a limited volume of solution the total final corrosion of the various grades is almost identical. Oxygen has a much smaller effect on corrosion in alkaline than in weakly acid solution. Localised attack and pitting of aluminium occurs only with purer grades of metal (99.8 and 99.992 per cent.) under the conditions chosen in these tests, and is retarded by the presence of oxygen. With less pure grades (99.2 to 99.5 per cent.) corrosion is uniform and general, and is slightly accelerated by the presence of oxygen.

Cost of Electricity—A Correction

We regret that, owing to a misprint, the price of electricity in a table of comparative costs per therm which Prof. Hay used to illustrate his lecture on "Melting Furnace Practice" (see our issue of January 16, page 35) was given as 1s. 2d., instead of ½d.

"The Nickel Bulletin"

On the front cover of our issue of January 23, in the advertisement of the Bureau of Information on Nickel, The Mond Nickel Company, Limited, of Grosvenor House, Park Lane, London, W.1, the number of the issue and volume of the "Nickel Bulletin" were transposed, and should have read: Volume 14, No. 1.

Metallography of Inclusions in Cast Irons and Pig-Irons

By H. MORROGH (British Cast Iron Research Association, Birmingham)

(*Continued from page* 58.)

Group II—Pink Inclusions

(a) Red-Pink and Idiomorphic Inclusions

This group comprises the inclusions usually referred to in the literature as titanium cyano-nitrides. These occur in nearly all cast irons in the form of small cubes. They are considerably harder than the metallic matrix and tend, usually, to stand up in appreciable relief. Whether viewed under dry or immersion objectives, they present brilliant surfaces. With regard to the occurrence of this constituent, it can be said that in cast irons it shows a marked tendency to occur associated with manganese sulphide in the extra-dendritic regions of the structure. This may be due to the fact that it forms from the melt in a similar manner to manganese sulphide. Titanium cyano-nitride is shown associated with manganese sulphide in Fig. 27. This titanium inclusion has also been observed in association with graphite. An example of this is illustrated in Fig. 28.

The term "titanium cyano-nitride" does not necessarily signify a definite chemical compound, but rather a solid solution of titanium carbide in titanium nitride, and so the ratio of titanium carbide to titanium nitride does not conform to a definite stoichiometrical relationship. The partial system titanium-carbide/titanium-nitride has been studied[45] and shown to yield a continuous series of solid solutions. These facts are in agreement with the observation that the colour of titanium cyano-nitrides in cast iron varies from deep salmon-pink to very faint pink. It is significant to note that the faint-pink cyano-nitrides usually occur with relatively high titanium contents and consequently with relatively large amounts of titanium carbide.

FIG. 27.—MANGANESE SULPHIDE ASSOCIATED WITH TITANIUM CYANO-NITRIDE. × 1,200.

Both titanium carbide and titanium nitride have cubic crystal structures, and, as would be expected, titanium cyano-nitride inclusions appear to be optically isotropic. Actually, when examined under polarised light between crossed nicols, they show a slight red coloration (particularly when an oil-immersion objective is used), which persists in all positions of the stage. Generally, they also show elliptical polarisation effects at their edges, owing to the fact that they tend to stand up in relief from the metallic matrix.

(b) Blue-Pink and Allotriomorphic Inclusions, and (c) Blue-Pink and Idiomorphic Inclusions.

Quite frequently, allotriomorphic pink inclusions, quite different in colour and morphology from titanium cyano-nitride, have been observed in certain pig-irons and cast irons. These inclusions, while being predominantly pink, were observed to have a faint bluish tinge, in contrast to the definite red appearance of the titanium cyano-nitrides. Again, examination between crossed nicols under polarised light revealed these inclusions to be anisotropic—titanium cyano-nitride is isotropic. They stand up in relief from the metallic matrix, and on this account it was difficult, at first, to detect any optical anisotropy, owing to the elliptically polarised light produced by reflection at large angles of azimuth at the curved edges of the inclusions. (A full description of their colour and optical properties is given later in this Paper when experiments which produced them synthetically are described.) The analyses of these samples were then carefully examined and it was found that they all had the following characteristics: A low manganese/sulphur ratio and small amounts of titanium. In every case the manganese content was insufficient to balance the sulphur content according to the formula[44]:—

$$\text{Mn per cent.} = (1.7 \times \text{S per cent.}) + 0.3$$

An example of a group of these inclusions is shown in Fig. 29. This micrograph was taken from a pig-iron having the following analysis:—T.C, 3.27; Si, 2.86; Mn, 0.29; S, 0.026; P, 1.42; Ti, 0.21; and V, 0.04 per cent. Inclusions of this type have been classified as those of Group II(*b*).

FIG. 28.—SMALL TITANIUM CYANO-NITRIDE CUBE ATTACHED TO END OF GRAPHITE FLAKE. GRAPHITE FLAKE IS IN ITS POSITION OF MINIMUM PLEOCHROIC ABSORPTION. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 2,000.

Also present in this sample were a number of perfectly idiomorphic inclusions of exactly the same colour and optical properties as the allotriomorphic blue-pink inclusions just described. These inclusions have been classified here as those of Group II(*c*). An example of the idiomorphic blue-pink inclusions is shown in Figs. 30 and 31.

With regard to the allotriomorphic blue-pink inclusions, it was observed that they occurred in a characteristic formation consisting of groups of parallel lamellæ, with each lamella tending to become bulbous at the extreme ends. This morphology is illustrated particularly well in Fig. 32, which was taken from a blast-furnace bear sample having the following analysis:—Mn, 0.11 per cent.; S, 0.024, and Ti, 0.07 per cent. When the lamellar allotriomorphic blue-pink inclusions in the pig-iron sample were examined at a very high magnification, it was observed that the lamellæ appeared to be in process of breaking up and that they were not always continuous. This is illustrated in Fig. 33.

The occurrence of these inclusions in titaniferous irons containing insufficient manganese to balance the sulphur suggested them to be probably titanium sulphide, and it is useful at this stage to consider the available literature pertaining to the presence of titanium sulphide in ferrous alloys. Portevin and Castro[45] observed that additions of titanium (0.5 to 1.0 per cent.) caused the sulphide phase in steels to change appreciably, giving irregular particles, harder and less deformable than manganese sulphide. These inclusions, the investigators say, are pale pink in colour, and from this point of view are difficult to distinguish from titanium cyano-nitride, but they are anisotropic. The analyses of the steel samples used by Portevin and Castro were:—

	No. 2. Per cent.	No. 7. Per cent.
C	0.080	0.35
Si	0.28	0.45
Mn	0.30	0.16
Ti	0.9	0.24
S	0.016	0.015
P	0.020	0.016

It is seen that there was insufficient manganese in these steels to ensure complete neutralisation of the sulphur in the form of manganese sulphide.

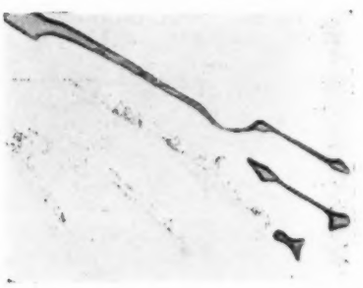


FIG. 29.—GROUP OF ALLOTRIOMORPHIC BLUE-PINK INCLUSIONS IN PIG-IRON. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

Blair and Shimer,[46] when investigating cast iron prepared from titaniferous materials, observed a sulphide which they isolated chemically. The product had a bronze colour and gave the following analysis:—Ti, 62.82 per cent.: Fe, 1.82; C, 9.82, and S, 22.64 per cent. Portevin and Castro suggest that this substance may be regarded as a titanium sulphide, more or less contaminated with carbide.

Hanemann and Schrader[47] (*loc. cit.*, No. 4, Table XXXI) have recorded a "rare constituent," similar in morphology to the allotriomorphic blue-pink inclusions previously described, which they suggest might be titanium sulphide. It is interesting to note that the iron containing the inclusion shown by Hanemann and Schrader has just insufficient manganese (actually 0.44 per cent.) to balance the sulphur (actually 0.10 per cent.) according to the formula: $\text{Mn per cent.} = (1.7 \times \text{S per cent.}) + 0.3$, and that the iron contains 0.02 per cent. of titanium.

Urban and Chipman[48] found that the addition of 1.26 per cent. of titanium to a synthetic alloy containing 0.15 per cent. of sulphur removed all the iron sulphide.

According to Mellor[49] titanium sulphide, TiS, is a reddish solid with a metallic appearance greatly resembling bismuth.

Since the facts available in the literature seemed to confirm the supposition that the blue-pink inclusions were probably titanium sulphides, it was decided to attempt to produce these inclusions artificially.

Experimental Work

Melt No. 1.—For this purpose Armco iron was heated with sugar charcoal until it melted and gave a white iron of approximately 3 per cent. total carbon content. The iron was then treated while molten with iron sulphide to give approximately 0.5 per cent. of sulphur. This base metal was cast into small pigs and broken up for subsequent melting. A quantity of 150 g. of the base iron was then melted in a small Silit-rod crucible furnace and as much ferro-carbon-titanium as possible was dissolved in the melt. Any excess ferro-carbon-titanium was removed from the surface of the metal by skimming; the crucible was then removed from the furnace and allowed to cool in air. The small ingot so obtained was fractured from top to bottom. The fracture was white with a few specks of grey. The composition of the product was sulphur 0.465 per cent. and titanium 0.41 per cent. The microscopic examination of the ingot showed the presence of a large number of allotriomorphic blue-pink inclusions, which exhibited exactly the same optical properties as those inclusions described previously. Generally, the pink inclusions, which may be tentatively termed titanium sulphide, were surrounded by a constituent resembling iron sulphide, but which actually was slightly darker, almost grey in colour, and which did not light up under polarised light between crossed nicols.

It would seem that this latter constituent is iron sulphide containing dissolved titanium (sulphide), and its etching properties were compared with those of iron sulphide in the following manner: Micro-specimens from the high-sulphur carburised Armco-iron pigs and from the titanium-treated crucible melt were etched together in a 1 per cent. aqueous oxalic acid solution.[50] After 1½ min. immersion in this solution at a temperature of 18.5 deg. C., the iron sulphide in the blank specimen was completely etched away, while the greyish constituent in the titaniferous melt was completely unattacked. Even after 6 mins. immersion in this etching reagent, neither the pink nor the grey constituents were attacked.

Further examination of the specimen at this stage gave the impression that all the iron-sulphide-rich component was not of the same colour. Some had a khaki tinge, while the rest had a grey coloration, and it was found that etching in a solution of ethyl alcohol saturated with stannous chloride[48] for 20 min. heightened the contrast between the grey and khaki components. By heat-tinting it was not found possible to differentiate between the grey and khaki parts—they both went deep purple, typical of iron-sulphide-rich inclusions. Micrographs showing typical formations of the allotriomorphic blue-pink and the grey-khaki inclusions are given in Figs. 34 and 35.

Now that it was known that the blue-pink inclusions could be produced synthetically, it was decided to determine the effect of increasing the manganese content of an iron originally containing these inclusions. To do this the following experiment was carried out.

Melt No. 2.—Sixty pounds of Swedish white iron were melted in an indirect rocking arc furnace. When the metal was molten, 5½ oz. of iron sulphide were added, stirred in, and then 1.2-in. dia. bar No. 1 was poured; 14½ oz. of ferro-carbon-titanium were added, the metal was reheated and then bar No. 2 was poured. This operation was repeated for additions of 1 lb. 3½ oz. and 2 lb. 7 oz. of ferro-carbon-titanium, and for additions of 2¾ oz., 5½ oz. and 11 oz. of 80 per cent. ferro-manganese, giving seven 1.2-in. dia. bars in all. The chemical analyses and the types of inclusions found are indicated in Table II.

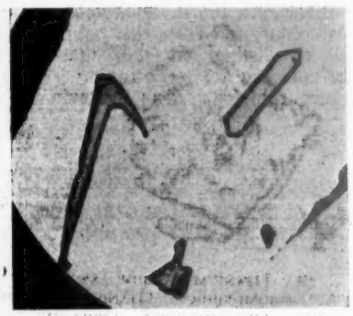


FIG. 30.—IDIOMORPHIC BLUE-PINK INCLUSION IN PIG-IRON. INCLUSION ON LEFT IS AN ALLOTRIOMORPHIC INCLUSION OF THE SAME COLOUR, ETC. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 31.—SAME SPOT AS FIG. 30 UNDER POLARISED LIGHT BETWEEN CROSSED NICOLS. OPTICAL ANISOTROPY OF THE IDIOMORPHIC INCLUSION IS INDICATED.

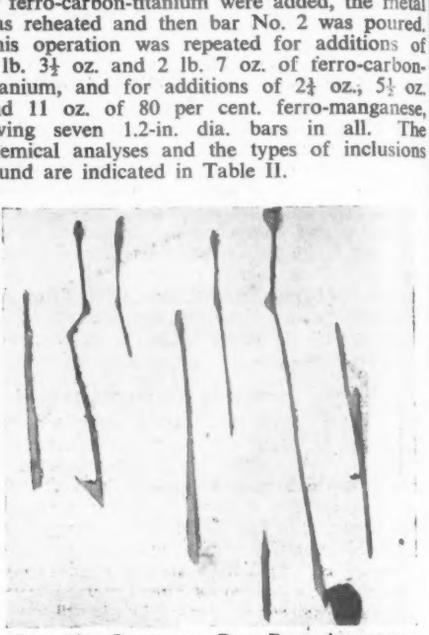


FIG. 32.—GROUP OF BLUE-PINK ALLOTRIOMORPHIC INCLUSIONS IN BLAST-FURNACE BEAR. 8-MM. DRY OBJECTIVE. UNETCHED. × 250.

FIG. 33.—DISCONTINUITY OF ALLOTRIOMORPHIC LAMELLAR INCLUSIONS. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 2,000.

FIG. 34.—GROUP OF BLUE-PINK INCLUSIONS ASSOCIATED WITH SMALL AMOUNT OF GREY-KHAKI IRON SULPHIDE CONTAINING TITANIUM. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

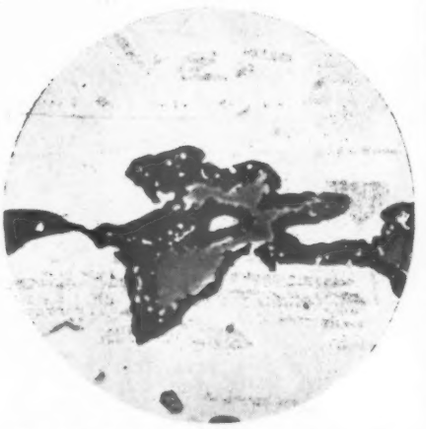


FIG. 35.—BLUE-PINK INCLUSION SURROUNDED BY LARGE AMOUNT OF GREY-KHAKI CONSTITUENT. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

TABLE II.—*Effect of Titanium and Manganese Additions to an Iron containing Iron Sulphide.*

Bar no.	Mn. Per cent.	S. Per cent.	Ti. Per cent.	Inclusions present.
1	—	—	—	Iron sulphide.
2	—	0.172	0.05	Iron sulphide and titanium sulphide detected.
3	—	0.162	0.06	Iron sulphide and trace of allotriomorphic titanium sulphide.
4	—	0.166	0.16	Iron sulphide and large amounts of allotriomorphic and idiomorphic titanium sulphide.
5	0.39	0.160	0.15	Large amounts of manganese sulphide and titanium sulphide, as No. 4.
6	0.96	0.145	0.13	Fairly large amounts of manganese sulphide. Trace of titanium carbide.
7	1.89	0.071	0.10	Manganese sulphide. Trace of titanium cyano-nitride.

The results given definitely indicate that additions of titanium to an iron containing iron sulphide results in the formation of a titanium sulphide and that manganese has a greater affinity for sulphur than has titanium. Additions of manganese to an iron containing titanium sulphide cause the disappearance of this constituent, until, when sufficient manganese is present to balance the sulphur, only manganese sulphide occurs. The fact that with increasing titanium contents in the above series, the allotriomorphic form of titanium sulphide occurred first and was followed by the idiomorphic form in the bar with the highest titanium content, suggests that the former probably remained dissolved until at least some of the metal was solid, and that the latter is a primary form which is deposited from the liquid.

Having determined the mode of occurrence of titanium sulphide formed by the addition of titanium to irons containing free iron sulphide, it was decided to try to prepare this constituent by the addition of iron sulphide to titaniferous pig-irons. Two pig-irons were chosen for this and a series of melts was made for each pig-iron with increasing additions of iron sulphide.

Melts Nos. 3-17.—The two pig-irons used for these series had the following percentage compositions:—

	T.C.	Si.	Mn.	S.	P.	Ti.	V.
A ..	4.00	2.60	1.10	—	—	0.60	0.50
B ..	3.6	2.06	1.57	0.058	1.04	0.23	0.07

For each melt, 100 to 150 grm. of the pig-iron were melted, and when molten the iron sulphide was added. The furnace employed was the Silit-rod furnace, as used for melt No. 1. After the iron sulphide addition, the metal was vigorously stirred with a silica tube; the metal was then allowed to stand in the furnace for a few minutes before the crucible was withdrawn and cooled in the air. No attempt was made to control the temperature. Immediately the iron sulphide was added to the metal it became covered with a thick solid manganese sulphide slag, which was not removed. When cold, the resulting ingots were fractured from top to bottom. One vertical section was used for microscopical examination and the bottom part of the other was drilled for chemical analyses where and when required. The ingots were drilled at the bottom, because the microscopical examination indicated segregation to have occurred at the tops of the ingots, owing to the upward settling of manganese and titanium sulphides. It was not considered necessary to have every ingot chemically analysed and only a selection was used for this purpose. However, the chemical analyses given illustrate the general trend of the changes in composition with the increasing iron sulphide additions (Table III).

The following general remarks can be made about these series of melts. With increasing additions of iron sulphide, the manganese content gradually decreases, owing to the rising of manganese sulphide. At the same time there is a corresponding decrease in the titanium contents, while, in the case of pig-iron A, the vanadium contents decrease only very slightly from the first to the last melt in this series. While there is sufficient manganese to balance the sulphur content, the only inclusions present are manganese sulphide, titanium carbide and vanadium carbide. As soon as the manganese content is lower than the value of (S per cent. × 1.7 + 0.3), titanium sulphide appears, first in the allotriomorphic form, then in the idiomorphic form. After this point, the titanium carbide is successively replaced by the idiomorphic titanium sulphide, which floats to the surface of the metal. This rising of titanium sulphide is not nearly so marked as that of manganese sulphide. The change in the fracture of the ingots from fine to coarse was accompanied by a corresponding change in the microstructure, from supercooled graphite to coarse flake graphite. This is very interesting in view of the known effects of titanium on the production of supercooled graphite, but it is impossible to tell whether the coarsening effect in this case was due to the gradual removal of the titanium or to the conversion of the titanium carbide to titanium sulphide.

A typical example of the allotriomorphic titanium sulphide in these series is shown in Figs. 36 and 37, actually taken from melt

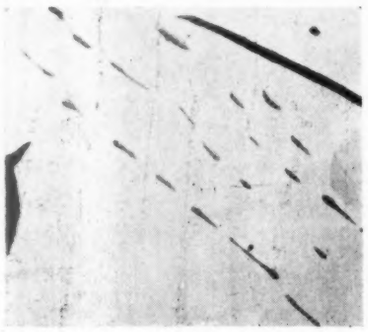


FIG. 36.—TYPICAL GROUP OF ANHEDRAL TITANIUM SULPHIDE INCLUSIONS. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

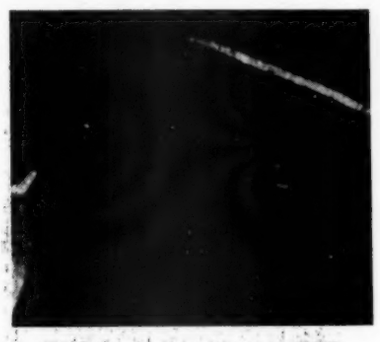


FIG. 37.—SAME SPOT AS FIG. 36 UNDER POLARISED LIGHT BETWEEN CROSSED NICOLS. × 1,200.

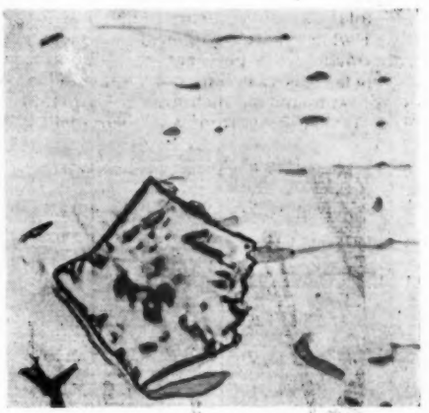


FIG. 39.—TITANIUM CARBIDE ASSOCIATED WITH ALLOTRIOMORPHIC TITANIUM SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,500.

FIG. 38.—VERY LONG LAMELLA OF ALLOTRIOMORPHIC TITANIUM SULPHIDE. FROM MELT NO. 15. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,500.

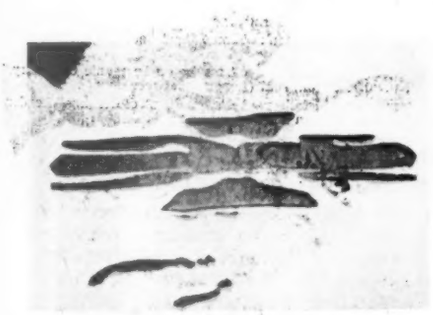


FIG. 40.—TYPICAL COMPLEX LAMELLAR IDIOMORPHIC TITANIUM SULPHIDE CRYSTAL.

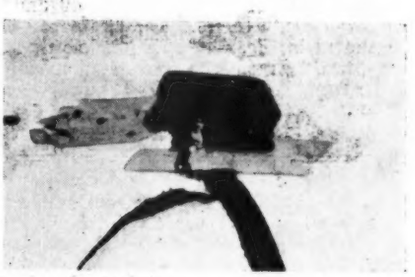


FIG. 41.—IDIOMORPHIC TITANIUM SULPHIDE ASSOCIATED WITH MANGANESE SULPHIDE AND GRAPHITE.

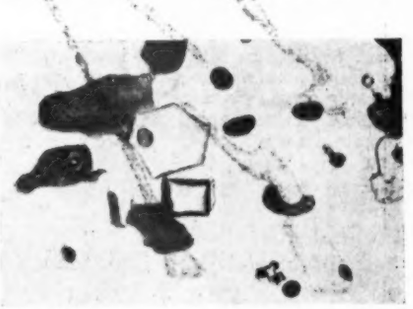


FIG. 42.—HEXAGONAL TITANIUM SULPHIDE ASSOCIATED WITH MANGANESE SULPHIDE AND CUBIC CRYSTAL OF TITANIUM CARBIDE.

FIGS. 40 TO 42.—2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

TABLE III.—*Effect of Iron Sulphide Additions to Two Pig-Irons.*

Melt No.	Charge.	Mn. Per cent.	S. Per cent.	Ti. Per cent.	V. Per cent.	Fracture.	Manganese sulphide.	Titanium carbide.	Vanadium carbide.	Titanium sulphide, allotriomorphic.	Titanium sulphide, idiomorphic.	Iron sulphide, titanium sulphide.
							PIG-IRON A.					
3	100 g. pig-iron, 0.55 g. FeS.	0.79	0.145	0.29	0.53	Very fine grey	Crystals ..	Large amounts	Eutectic-like groups.	Not present ..	Not present ..	Not present.
4	93 g. pig-iron, 1.5 g. FeS.	—	—	—	—	Slightly-coarser than No. 3.	Crystals ..	Do.	Do.	Trace	Do.	Do.
5	140 g. pig-iron, 3 g. FeS.	0.79	0.452	0.13	0.52	Slightly coarser than No. 4.	Large amounts	Few crystals ..	Do.	Eutectic-like groups of spots and lamellæ.	Large crystals	Do.
6	150 g. pig-iron, 4 g. FeS.	—	—	—	—	Similar to No.5	Do.	Do.	Do.	Do.	Lamellar idiomorphic crystals.	Do.
7	150 g. pig-iron, 5 g. FeS.	0.57	0.501	0.10	0.49	Patches of coarse and fine grey.	Large amounts in dendrites.	Traces ..	Do.	Do.	Do.	Do.
8	150 g. pig-iron, 6 g. FeS.	—	—	—	—	Similar to No.7	Large amounts	Do.	Do.	Do.	Do.	Do.
9	150 g. pig-iron, 7 g. FeS.	0.47	0.494	0.04	0.41	Similar to Nos. 7 and 8.	Do.	None present ..	Do.	Do.	Do.	Do.
10	150 g. pig-iron, 10 g. FeS.	0.33	0.331	0.08	0.43	Coarse grey ..	Fairly large amount.	Do.	Do.	Do.	Do.	Traces.
11	126 g. pig-iron, 12.6 g. FeS	0.14	0.947	0.08	0.33	White with grey rim.	Not present ..	Do.	Not present ..	Not present ..	Not present ..	Large amounts.
							PIG IRON B.					
12	146 g. pig-iron, 0.5 g. FeS	1.40	0.183	0.10	—	Fine grey ..	Fair amounts	Large cubic crystals.	Trace	Not present ..	Not present ..	Not present.
13	140 g. pig-iron, 1 g. FeS.	—	—	—	—	Do.	More than No. 12.	Do.	Do.	Do.	Do.	Do.
14	158 g. pig-iron, 5 g. FeS.	0.76	0.329	0.06	—	Slightly coarser	As No. 13. ..	Do.	Do.	Trace	Do.	Do.
15	148 g. pig-iron, 6 g. FeS	—	—	—	—	Coarse grey ..	Do.	Less than No. 14	Do.	Fair amount ..	Fair amount ..	Do.
16	149 g. pig-iron, 7 g. FeS	0.56	0.281	0.03	—	Do.	Less than No. 15.	Very small amount.	Do.	As No. 15 ..	As No. 15 ..	Do.
17	145 g. pig-iron, 9 g. FeS	0.52	0.394	0.06	—	Mottled ..	Not present ..	Not present ..	Not present ..	Not present ..	Not present ..	Present in round blobs.

No. 10. In these micrographs it would appear that the titanium sulphide was originally lamellar, but at some later time spheroidisation took place. This idea is further emphasised by the composite micrograph in Fig. 38, taken from melt No. 15, showing a very long streak of the allotriomorphic titanium sulphide. Spheroidisation appears to have occurred in several places. In the early stages of the removal of titanium carbide, this constituent frequently occurs associated with allotriomorphic titanium sulphide. This is illustrated in Fig. 39, taken from melt No. 14.

In the case of the idiomorphic titanium sulphide, it was possible to observe its morphology and optical properties much more easily than previously. Large, well-formed crystals of the sulphide were present in melts Nos. 5 to 10, 15 and 16. These crystals have either a complex lamellar form or a hexagonal outline. Typical lamellar forms are shown in Figs. 40 and 41, taken from melt No. 10. The hexagonal form is illustrated in Fig. 42. It is possible that this latter form is merely a cross-section of the lamellar form.

(To be continued.)

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Beneficial Effects of Zirconium in Cast Nickel-Silicon Bronzes

(Continued from page 69.)

with tests on straight nickel-silicon bronze castings, which showed an average of only about 22.3 tons per sq. in., with probably 35 per cent. of the test-bars having less than 15.65 tons per sq. in. ultimate tensile strength, a remarkable advantage was noted in the addition of zirconium.

Fig. 2 gives a graphic illustration of the tensile strength of test-bars from the first 12 production heats to which 0.25 per cent. Zr was added as compared with 12 successive heats of straight nickel-silicon bronze. The test results are arranged in order of increasing tensile strengths. This graph clearly shows the distinct improvement brought about by the additions of zirconium. Not only is the average strength considerably higher, but, more important, there are no test-bars showing a tensile strength below 24.55 tons per sq. in., whereas about 35 per cent. of the tests on straight nickel-silicon bronzes show an ultimate tensile strength below 15.65 tons per sq. in. and only 15 per cent. above 24.55 tons per sq. in.

In addition to test-bars from production heats, several test-bars from small experimental melts showed equally good tensile strengths. Variation of the zirconium content from as little as 0.1 per cent. up to 1 per cent. did not affect the results. Figs. 3 and 4 offer a possible explanation of the beneficial effects of zirconium.

In all tests with additions from 0.08 per cent. up to 0.73 per cent. Zr the grain boundaries were relatively fine and free from excessive segregation. The addition of zirconium had no ill-effects on the hardness and electrical conductivity of the alloys.

Fig. 5 shows typical ageing curves on a nickel-silicon bronze to which 0.25 per cent. Zr was added. Hardness reaches a maximum of approximately 90 Rockwell B after 16 hrs. at 450 deg. C. and conductivity reaches approximately 37 per cent. I.A.C.S. after the same length of time. Fig. 6 shows a stress-strain curve on the same alloy. The ultimate tensile strength was 30.6 tons per sq. in.; yield strength at 0.2 per cent. elongation, 27.25 tons per sq. in.; proportional limit, 20.1 tons per sq. in.

The information presented in this Paper is primarily a *résumé* of factual data. The research work concerning the theoretical explanations is not complete. As mentioned before, the microstructure of the straight nickel-silicon bronzes indicates that the extreme brittleness is in some way connected with the type and location of the precipitate found during ageing after quenching. Possibly the presence of zirconium —which in itself, or in combination with another element, can be used as a precipitation-hardening constituent in copper—may alter the precipitate (either in respect to type or location) sufficiently to eliminate the intercrystalline weakness and general embrittlement found in cast nickel-silicon bronzes. Furthermore, zirconium is a most efficient degasifying agent, producing castings free from gases usually occluded within the grain boundaries. It seems quite possible that occluded gases may be the cause of incipient cracks during heat-treating. Another advantage of the zirconium addition was the effect on the formation of nuclei by zirconia, resulting in a finer grain structure.

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The Week's News in Brief

Trade Talk

THE LEWIS FOUNDRY AND MACHINE DIVISION of the Blaw-Knox Company of Pittsburg is undertaking a £40,000 extension to cope with increasing business consequent upon the American defence programme.

DEPOSITS OF WOLFRAM ORE have been discovered in Jugoslavia, along the Adriatic coast. In the past Jugoslavia has produced only small quantities of wolfram. No details are yet available as to the extent of the deposits.

JOHN COCKERILL, the Belgian iron and steel and coal-mining concern, report a net profit in 1939-40 of 67,200,000 fcs., after 52,900,000 fcs. depreciation, as against a profit of 63,200,000 fcs. in 1938-39. The dividend has been increased from 33.61 fcs. per share to 44.16 fcs.

EMPLOYEES of Harland & Wolff, Limited, at Govan, have contributed £700 to the City of Glasgow Central War Relief Fund. The sum of £140 has been contributed to local charitable institutions during 1940 by employees of the Atlantic Engine Company (1920), Limited, Wishaw.

ALLEGHENY LUDLUM STEEL CORPORATION, Brackenridge, Pa., has announced a $2,000,000 expansion programme to increase its alloy-steel capacity by 50,000 tons a year. The expansion will give the company increased electric furnace melting capacity and a corresponding increase in finishing facilities.

ACCORDING TO A MESSAGE from Teheran, considerable progress has been made in the erection of blast furnaces between the Iranian capital and Kazvin. Work was started on the plant in 1939. The furnaces are expected to be ready for operation next year. Considerable deposits of ironstone are found in the vicinity.

MEN IN THE engineering and shipbuilding trades are to receive a war bonus increase of 3s. 6d. a week. This was the decision of the National Arbitration Tribunal, announced last week, on claims made on behalf of these workers. There were two claims; one by the Amalgamated Engineering Union and the National Union of Foundry Workers for a 12s. increase, the other by the Confederation of Shipbuilding and Engineering Unions and the Engineering Joint Trades Movement for 10s. a week, with an equivalent for piece-workers. It is estimated that the increases will cost the industries some £9,000,000 a year.

THE NATIONAL SURVEY which has been undertaken by the Ministry of Supply (Iron and Steel Control) to record and classify all available fixed and demolition scrap iron has been extended to the Midland counties. Letters have been dispatched to surveyors and sanitary inspectors in Cheshire, Shropshire, Staffordshire, Derbyshire, Leicestershire, Nottinghamshire and Lincolnshire, who are co-operating in the work. The whole of Scotland, London, Glamorgan and Somerset, and all the northern counties of England, have been surveyed, and encouraging reports are being received from every area. Shortly a start will be made with Wales (excluding Glamorgan).

IN SEPTEMBER LAST, a fund was opened by the employees of British Insulated Cables, Limited, for the provision of a "Spitfire," for the nation, the company subscribing an amount equal to the total subscribed by the employees. So enthusiastic was the response that a cheque for £5,000 was forwarded to the Ministry of Aircraft Production within a few days of the fund's inception. The B.I. Fund has now closed with a total of £6,148 and a cheque for the balance has been forwarded to Lord Beaverbrook, in acknowledgment of which he expresses "his warmest thanks for this gift and his deep appreciation of the spirit of generous patriotism which prompted all who subscribed to it."

THE MINISTRY OF LABOUR AND NATIONAL SERVICE has issued a leaflet (P.L.82) on auxiliary training in employers' workshops for wartime work in the engineering industry. This type of training is additional to the training undertaken by employers for their own needs, and no trainee is subsequently placed in employment with the firm by which he or she is trained. The courses do not normally last longer than eight weeks, and during that time the trainees work for the normal factory hours of the works in which they are trained. Allowances are paid by the Ministry during the period of training. A number of these courses are already in operation, but more recruits, both men and women, are urgently needed in order that existing courses may be filled and new courses started. Inquiries or applications for training should be made at any Employment Exchange, where copies of this and other training leaflets are available.

THE NON-FERROUS METALS CONTROL announce that they are prepared to buy brass ingots of a defined analysis at £35 per ton f.o.r. makers' works. This offer is made in order to create a market for the disposal of heavy brass and other forms of lower-grade brass scrap, and the analysis of the brass ingots has been drawn up accordingly. The ingots must be of good commercial quality and comply with the following percentage analysis:—Copper, 62.0 to 65.0; tin, 0.75 to 1.5; lead, 3.5 max.; iron, 0.5 max.; nickel, 0.5 max.; aluminium, 0.01 max.; total of all other elements except zinc, 0.5 max.; and zinc, balance. An analysis must be supplied with each lot; for lots of over 5 tons, one analysis will be required for each separate 5 tons or part thereof. Each ingot must weigh not less than 14 lbs. or more than 28 lbs., and before purchasing, the Control reserve the right to inspect and sample all ingots offered and to refuse to purchase any that do not comply with the requirements of the specification. After acceptance the manufacturer will be required to stamp each ingot with the letters N.C.B. Inquiries should be addressed to the Joint Controllers, Non-ferrous Metals, Grand Hotel, Rugby.

Personal

MR. GILBERT LAURIE ANDERSON has resigned his directorship of Federated Foundries, Limited.

MR. WILFRED JAMES TURNBULL, for over 38 years principal of Turnbull's Foundry, Barrow-in-Furness, and Mrs. Turnbull have celebrated their golden wedding. He retired from business about two years ago.

FIFTY-SEVEN YEARS of unbroken service is claimed by Mr. T. Brisbane, who has just retired from the foundry dispatch department of Dobbie, Forbes & Company, Limited, ironfounders and stove and range makers, of Larbert.

THE COUNCIL of the Institution of Mechanical Engineers have awarded the Hele-Shaw National Certificate Prize for 1940, accompanied by the Hele-Shaw Medal, to George Nuttall, a student at Burnley Municipal College, who is deemed to have shown outstanding industry and merit throughout complete part-time courses leading to the award of the Ordinary National Certificate in 1938, with two distinctions, and of the Higher National Certificate in 1940, with three distinctions, and to have complied with the condition as to training in engineering workshops with Butterworth & Dickinson, Limited, textile machinists and founders, of Burnley.

Wills

LUDLOW, W. S., for forty years works manager of Baldwins, Limited, Swindon Works, near Dudley £1,018

KINCAID, J. S., Renfrewshire, chairman and managing dirccter of John G. Kincaid & Company, Limited, marine-engine builders £124,588

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Van Leer Auto Die-Castings, Limited, Midland Bank Chambers, Howardsgate, Welwyn Garden City—Capital, £100.

Walsall Sandblasting Company, Limited—Capital, £500. Subscriber: F. E. Richards, 135, Walsall Road, Little Aston, Sutton Coldfield.

Knete Castings, Limited, Childerditch, Brentwood, Essex.—Capital, £100. Directors: E. N. Griffiths, A. C. Howard, T. A. Rose, and R. B. Minto.

Premier Tool & Die Company, Limited, Acacia House, High Street, Harmondsworth, Middlesex—Capital, £100. Directors: J. Johnson, F. D. Gaunt, and E. Phillips.

Obituary

MR. R. A. GOLDING, son of the late Mr. Richard Golding, a former director of William Jacks & Company, Limited, and himself a well-known Middlesbrough iron and steel merchant, died on January 16 at his home at Redcar.

THE DEATH has occurred of Mr. James Taylor, consulting engineer, of Path Street, Glasgow, who lately represented Newton Chambers & Company, Limited, Sheffield, and the Wellman Smith Owen Engineering Corporation, Limited, of London.

THE DEATH has occurred, at his residence, Hosie House, Hosie Court, Westerham, Kent, of Mr. T. U. Hill, who, until he retired in 1935, occupied the position of London manager of The Carborundum Company, Limited, Trafford Park, Manchester. Mr. Hill joined the company in 1907 and took a leading part in the rapid growth of the abrasive industry in this country.

MR. JOHN H. SILLEY, O.B.E., who died last week at Port Navas, Cornwall, was chairman and managing director of R. & H. Green and Silley Weir, Limited, ship repairers and founders, of London, and was also on the board of three other ship-repairing companies. He was associated with the Institute of Marine Engineers for more than 40 years and was elected President in 1934. Recently, Mr. Silley had started a Spitfire Fund for Falmouth with a gift of £1,000.

MR. ALVIN IRWIN FINDLEY, who was for 20 years editor of the "Iron Age," died last month at St. Petersburg, Fla. He retired from active work in 1930. Mr. Findley became associate editor of the "Iron Age" in 1905 and was made editor-in-chief in 1911. From 1892 to 1905 he was editor of the "Iron Trade Review" of Cleveland (now known as "Steel"). Mr. Findley was for many years a member of the American Iron and Steel Institute, the Iron and Steel Institute (British), American Institute of Mining and Metallurgical Engineers, American Foundrymen's Association, the American Society for Testing Materials, and other technical bodies. He was in his 82nd year.

Reports and Dividends

Allied Ironfounders (Ireland), Limited—Profit to June 30 last of £427, reducing the debit balance carried forward to £16,271.

Herbert Morris, Limited—Dividend for the half-year to January 31, 1941, on the 5 per cent. (free of income tax up to 6s. in the £) cumulative preference shares.

J. & E. Hall, Limited—Net profit for the year to September 30, £65,841; brought in, £39,447; income tax, £17,000; ordinary dividend of 8½ per cent.; carried forward, £43,008. Meeting, February 20.

Contracts Open

Bromley Cross, February 22—Cast-iron goods for the year ending March 31, 1942, for the Turton Urban District Council. Mr. Reginald Dart, engineer and surveyor, Council Offices, Bromley Cross, near Bolton.

London, N., February 14—Pipes and fittings, tools, etc., for the Tottenham Borough Council. Mr. E. Townson, town clerk, Town Hall, Tottenham, London, N.15.

Forthcoming Events

FEBRUARY 1.

Institution of Mechanical Engineers (North-Western Branch):—"Power and Combustion," Thomas Hawksley Lecture by Prof. A. C. G. Egerton, in Manchester, at 2.30 p.m.

FEBRUARY 3.

Royal Society of Arts:—"Influence of Art on Instruments of War," third Cantor Lecture by J. G. Mann, in London, at 1.45 p.m.

FEBRUARY 5.

Manchester Metallurgical Society:—"Magnetic Materials," Paper by D. A. Oliver, in Manchester, at 6.30 p.m.

FEBRUARY 6.

Institute of Metals (Birmingham Section):—"Spectroscopic Analysis," Paper by F. Twyman, in Birmingham, at 6.30 p.m.

Institute of British Foundrymen

FEBRUARY 6.

Lancashire Branch:—"Melting and Casting Problems in the Production of High-Strength and Special-Duty Alloy Iron Castings," Paper by A. E. McRae Smith, in Manchester, at 3 p.m.

Scottish Branch:—"Making Rope Pulleys," Paper by J. F. Webster, in Glasgow, at 3 p.m.

West Riding of Yorkshire Branch:—Discussion of "Gas in Liquid Cast Iron," Paper by W. Y. Buchanan, in Bradford, at 6.30 p.m.

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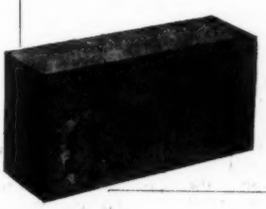

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Raw Material Markets

Foundrymen, on the whole, are extremely busy and are consuming substantial tonnages of iron and also scrap metal, the latter being used more extensively now in order to relieve the pressure on ironmakers. Manufacturers of light castings are still in need of work, but other sections of the trade are operating to capacity. Generally speaking, adequate tonnages of iron are forthcoming, with primary consideration given to the requirements of high-priority consumers. High-phosphorus iron, which is produced from home ores, is in ample supply, but considerable care has to be exercised in the allocation of hematite, while low-phosphorus iron, too, is delivered only to users on work of national importance in most instances.

Pig-Iron

MIDDLESBROUGH—Ironmakers in this area are largely concerned with the production of basic iron for the steel industry, and local outputs of foundry iron and hematite are negligible compared with the high rate of consumption of these descriptions. However, foundrymen are able to obtain their needs from the Midlands and deliveries from Derbyshire and Northamptonshire furnaces are satisfactory and facilitate, in fact, the accumulation of small stocks. Heavy engineering concerns generally can accept fresh business only under official direction, being almost solely engaged in catering for the needs of Government departments. Makers of light castings are much better employed than they were a few months ago, but there is still room for improvement and order-books are by no means filled in a number of cases.

Supplies of hematite are being distributed by the Control authorities with the utmost care, as shortage of the special ores required for production has resulted in the demand outpacing outputs by a considerable margin. Certain furnaces have been temporarily transferred to the manufacture of other descriptions of iron. In existing circumstances it has become imperative for larger imports of American hematite to be brought into the United Kingdom, and these supplies are doing much to alleviate the situation. It has been found possible in some cases for hematite users to make use of other types of iron, and pressure has been eased to some extent in this way.

LANCASHIRE—Speciality engineers and heavy engineering establishments continue to operate at capacity levels, with a regular flow of replacement orders to fill the breach caused by completed contracts. Hence, pig-iron consumption in these branches is maintained on a substantial scale. Buyers are obtaining their requirements from the Midlands, ironmasters there being in a position to meet current orders, but little opportunity is afforded for the accumulation of reserve stocks. Consumption of iron among jobbing foundrymen has tended to decline of late, owing to the lack of fresh business. There are exceptions, however, and jobbing foundries associated with the machine-tool trade have as much work on hand as they can conveniently handle at the present time. The position of the light-castings industry continues to show improvement, but progress is slow and many firms have insufficient work to maintain full-capacity operations.

MIDLANDS—With a wider range of products now being made, many light-castings manufacturers are doing a considerable volume of work on Government account, and, consequently, the demand for high-phosphorus iron from this trade has shown a marked expansion of late. No difficulty is experienced in meeting all inquiries, however, and some concerns have been able to lay down small ground stocks. A better demand for light castings has also set in from the building trade, so that, on the whole, business has become quite brisk, and is certainly more active than at any time since the outbreak of the war. Heavy engineers are using considerable tonnages of special irons; hematite is not easy to acquire, and the call for refined irons has increased in consequence. Quite large shipments of hematite are being diverted to Midland users, but no encouragement is given for the utilisation of hematite where it is possible to substitute some other grade. Low-phosphorus iron, also, is by no means plentiful, but essential users are being kept well supplied.

SCOTLAND—While the demand for pig-iron outstrips local production, the margin is made up by the acquisition of supplies from other home sources and also by the use of foreign material. Heavy foundries, being employed on Government contracts, are classed as priority users, and are thus given preferential treatment in the allocation of supplies. A stronger call for foundry iron is emanating from light-castings works in the Falkirk district, as activity among these concerns has quickened appreciably of late, although it cannot be said that operations have yet reached really satisfactory proportions taking the trade in its entirety. Iron for these works is bought in the Midlands and sufficient material is available.

Coke

On the whole, the foundry coke position is satisfactory, consumers having adequate supplies on hand. This is due to most users having accumulated reserve stocks over a lengthy period, and these have been of particular value recently owing to certain delays in the arrival of fresh supplies. Ovens are discharging their commitments against contracts according to schedule, but coke is still being held up in transit. Business is largely conducted on a contract basis, there being little day-to-day buying.

Steel

There is little hope of any early relaxation in the conditions relating to purchases of steel, as all the available material is fully accounted for under Government contracts or by other uses accredited by the Iron and Steel Control. Home production is being maintained at very gratifying levels, but it is necessary to bring in considerable tonnages of foreign steel in order to cope with the unprecedented demand. Steelmakers in the United Kingdom are maintaining a steady flow of deliveries to the consuming works, and the existing distribution arrangements ensure that urgent needs are satisfied, although often at the expense of ordinary domestic requirements.

Scrap

Deliveries of the usual descriptions of iron and steel scrap are quite satisfactory, and many consumers have been able to put down extensive stocks. Consumption continues to expand, but no difficulty is being found in meeting the demand, and fresh tonnages are regularly being received. A considerable quantity of demolition scrap metal is now awaiting collection prior to grading, and an early start in this respect is desirable, as the present happy position of the scrap market must not be allowed to overshadow the need for preparing for the future.

Metals

The American copper situation shows no sign of becoming any easier, and metal for prompt delivery is very difficult to come by. The possibility of the Metals Reserve Company releasing copper during February is still being canvassed. It is reported that the company intends to purchase an additional 100,000 tons of copper from Latin America, which will supplement the similar quantity already negotiated. Owing to the acute shortage of domestic copper, Customs smelters and the Defence Commission have lately been discussing the question of price stabilisation. The present situation has induced the U.S. Government to request that productive capacity of brass be raised by 25,500 short tons per month, which is expected to result in about 18,000 short tons of copper a month becoming available.

Prices of tin in London have tended to decline of late, despite increased activity on the market. It is reported that the United States Government has now purchased 40,000 tons of tin, leaving 35,000 tons to be bought before the end of June. Consumption of tin, both here and on the other side of the Atlantic, continues to absorb heavy quantities—mainly in connection with munitions.

The Minister of Supply has requisitioned about 8 tons of Chinese refined tin lying at New Crane Wharf, London, E.1, warrant Nos. 4,946 and 5,155. Applications for compensation should be sent to the Joint Controllers, Non-Ferrous Metals Control, Grand Hotel, Rugby. The price of the requisition is £257 per ton, London Metal Exchange standard tin contract terms, and invoices and warrants should be sent with the applications. Rent should be deducted on the invoice up to and including November 30, 1940.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £256 to £256 5s.; Friday, £256 5s. to £256 10s.; Monday, £256 15s. to £257; Tuesday, £257 to £257 5s.; Wednesday, £256 10s. to £256 15s.

Three Months—Thursday, £257 5s. to £257 10s.; Friday, £257 5s. to £257 10s.; Monday, £257 5s. to £257 10s.; Tuesday, £258 to £258 5s.; Wednesday, £257 10s. to £257 15s.

The zinc position here remains little changed: essential requirements are being met quite readily, but there is very little to spare for other users. The U.S. spelter situation is tight, and efforts are being made to bring into operation further smelting facilities, but this, of course, will take time, and the benefit will not be felt for a considerable period.

Company Meeting

Allied Ironfounders (Ireland), Limited

The difficulty of importing raw materials was stressed by Mr. R. J. HEARNE (chairman) at the annual meeting in Dublin recently, at which a committee was appointed to confer with the directors on the management of the business. Mr. Hearne said that conferences and preliminary negotiations had taken place in an effort to overcome present import difficulties, and the shareholders might be satisfied that the directors would not commit them in any way without putting all the available information before them. Notwithstanding these difficulties, the foundry had been operating successfully, and the output and volume of business had been substantially increased. In the whole year sales had increased 33½ per cent. The balance sheet had been abridged this year, it being desirable in view of determined opposition to withhold from competitors any indication of the firm's activities, extension of plant and other business. The directors were satisfied that the best use was being made of the assets of the company. Mr. John Harpur, a shareholder, criticised the transfer to the English company of debentures to the value of £20,000, and asked whether any steps had been taken to meet this amount when it became due. Another shareholder, Alderman J. Awlward, said that the shareholders in Waterford were not satisfied with the way the company was being run. The directors had committed themselves by the issue of the debenture shares to the English company. Mr. Hearne was unanimously re-elected director.